Climate Change Risk Assessment and Adaptation Plan

Final Risk Assessment Report

15 April 2009

TABLE OF CONTENTS

Page

1. Summary

Climate change is emerging as a critical issue for Australian communities. Even with international action to reduce greenhouse gas emissions, the global climate is projected to undergo significant change in the 21st Century, with the potential to create many risks as well as opportunities. It is important that the impacts of climate change are addressed at the local level, since local attributes including socio-economic characteristics and the physical environment will significantly determine the extent of the risks, as well as the nature of adaptation responses.

Recognising this, the Commonwealth Government has provided funding through the Local Adaptation Pathways Program (LAPP) to help councils undertake climate change risk assessments to identify likely impacts of climate change on council operations, and develop action plans to prepare for the likely local impacts of climate change. Redland City Council (RCC) is one of over 60 council that have secured funding in the first round of LAPP.

This is a report of a climate change risk assessment conducted on behalf of Council by Marsden Jacob Associates (MJA) and Broadleaf Capital International (Broadleaf) as the first step toward developing a Climate Change Risk Assessment and Adaptation Plan. The purpose of the risk assessment was to explore the ways in which climate change may impact on Council assets and services, and to obtain a prioritised register of risks that could be taken forward as the focus for the adaptation plan.

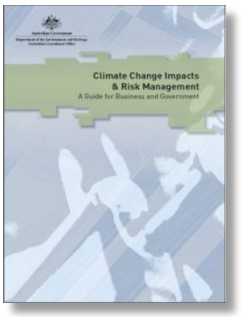
The project is funded in part by the Australian Government Department of Climate Change, and will be undertaken in two stages:

- *Climate Change Risk Management* – identifying and prioritising climate change risks.
- *Climate Change Adaptation* – developing an adaptation plan that will help RCC to mitigate key climate change threats and realising any opportunities.

The Climate Change Risk Management component of the project has been carried out in the following seven discrete steps:

- Preliminary Desktop Analysis;
- Risk Assessment Workshops;
- Draft Risk Assessment Report;
- Issues Paper;
- Preliminary Spatial and Other Assessments; and
- Final Risk Assessment Report.

More detailed spatial modelling of sea level, storm surges, severe storms and flooding will follow. This work was delayed due to: (a) the decision by RCC to commission a review of the existing work of Cardno Lawson Treloar (Cardno); and (b) the further delay while Cardno completed their study and provided us with their datasets.



The risk assessment followed the approach described in the Australian Greenhouse Office publication, *Climate Change Impacts and Risk Management: A Guide for Business and Government*. Broadleaf and MJA authored the *AGO Guide*, which is based on the Australian standard for *Risk Management* AS/NZS4360 (2004).

The assessments utilised the RCC risk evaluation framework, which is described in its *Risk Assessment Handbook* and précised in Section 2.

In brief, forty-eight (48) risks were identified against five Key Elements and 31 Risk Categories. None of these was rated Extreme under any of the three time horizons upon which the assessment was based (current, 2030 and 2070). A synopsis of ratings and priorities (Figure 4) showed that risks to Infrastructure dominated the results overall, and dominated the Medium-High ranks. This was most obvious for short-term risks, but the trend persisted for all three time periods considered (immediate, 2020, 2070). One risk to Corporate Services was also highly ranked. Eleven risks were accrued to Environmental Management and ten to Community and Social Planning. A small number of these achieved a High rating in the longer term (2070). Risk differences were also assessed (Table 8), and illustrated the extent to which key risks were expected to change over the three times periods. The extent of change reflects both the sensitivity to the particular climate change variable(s) concerned — in particular, the proximity of any critical climate thresholds — and the extent to which identified controls are able to mitigate the increasing pressure from climate change.

The risks and priorities obtained from the risk assessment workshop are listed in the risk register in Appendix 1 (page 99). Some preliminary spatial and other assessments have been carried out to better understand key issues that arose during the process. These assessments are documented in section 4. The risk register and preliminary assessments will be taken forward to the adaptation planning component of the project.

The report also highlights some areas where follow-up spatial risk assessment and other forms of desktop assessment will help to clarify or substantiate individual risks or risk ratings (section 5). We do not maintain that all of this work need be done immediately, and suggest only that RCC review the summary and, where relevant, the more detailed discussions of each risk, and draw their own conclusions about the assessments that they consider most critical to the integrity of the exercise.

2. Risk Management Process

The climate change risk management component of the project followed the approach and terminology described in the Australian Greenhouse Office (AGO) publication, *Climate Change Impacts and Risk Management: A Guide for Business and Government*. Broadleaf and MJA authored the *AGO Guide*, which is based on the Australian standard for *Risk Management* AS/NZS4360 (2004).

Under this approach, risk management includes the five key steps shown in Figure 1. The first step commonly requires some desktop research and analysis, while the second-through-to-fourth steps are carried out at a risk assessment workshop. The final stage can also be initiated at the risk assessment workshop, although more typically is the focus of a follow-up adaptation planning step.

The RCC climate change risk assessment follows the generic process in general terms, although, as noted above, included some additional desktop elements.

Figure 1: Steps in the risk management process

Source: Climate Change Impacts and Risk Management: A Guide for Business and Government (AGO, 2006)

2.1. Scope of the Assessment

The RCC Project Brief explained that the risk assessment should encompass all of the roles and responsibilities of Council that might be affected by climate change.

These included:

- Provision of infrastructure including the management and maintenance of assets;
- Provision of services to the community;
- Operational works;

- Planning and management of development and land use; and
- Land and water management.

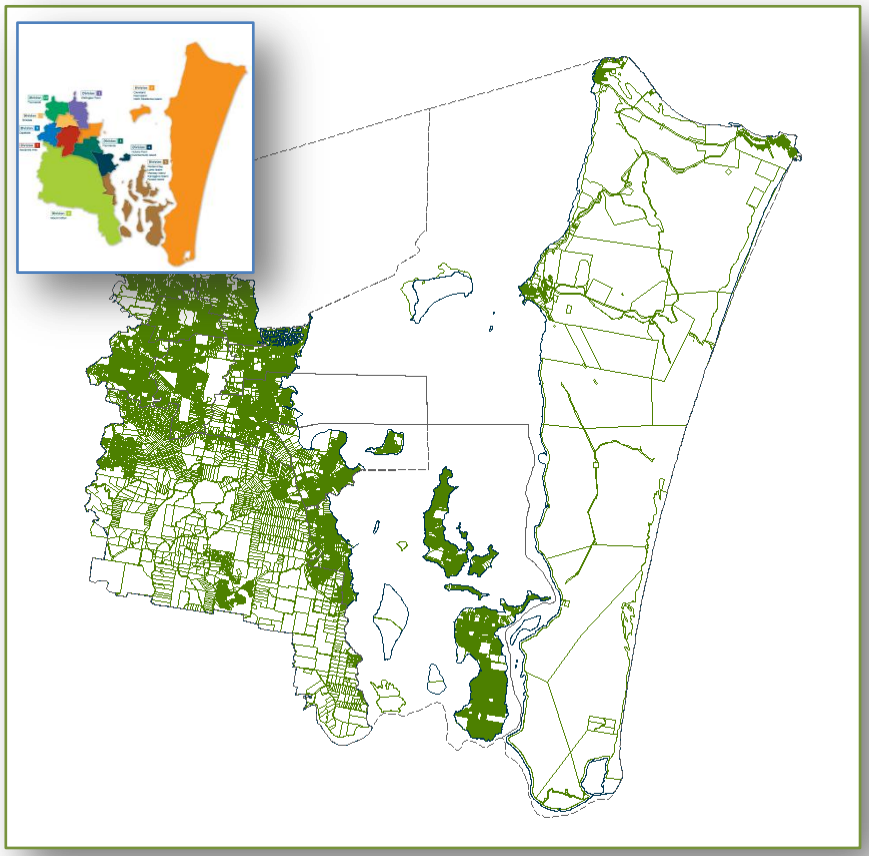
The Project Brief also indicated that the risk assessment should not extend to Redland Water and Waste (RWW) water or wastewater bulk supply, transport, or distribution. The state government water reforms in southeast Queensland (southeast Queensland) remove and transition most of RWW into new State-operated regional water businesses for which the planning horizon is now substantially outside the scope of Council influence. We note in particular that:

- The bulk supply entity now controls RWW major water supply assets (handed over on 30 June 2008), including Leslie Harrison Dam, Capalaba water treatment plant, North Stradbroke Island (NSI) bore fields and the NSI water treatment plant.
- The bulk transport entity now controls the main trunk water pipeline from NSI to Heinemann Road reservoir, together with the bulk main from Capalaba treatment plant, Alexandra Hills reservoir and Heinemann Road reservoir (as of 30 June 2008).
- The water and wastewater reticulation and wastewater treatment plants will be transitioned to a new single water distribution business by July 2010, with the retail functions moving to a separate retail business at the same time.

The project covered the entire geographic area within the boundary of the city on the mainland, North Stradbroke Island (NSI) and the Southern Moreton Bay islands (SMBI). This includes the area down to mean low-water mark along the entire foreshores of the Bay and ocean coasts.

We note that this is a further extent than indicated by the city boundary on the digital cadastral database issued by Department of Natural Resources and Mines (Figure 2). Almost uniquely, many of Council's responsibilities extend to low water under previous proclamations of Governor in Council and overlap with the Moreton Bay Marine Park jurisdiction.

Figure 2: City of Redland



Source: digital cadastral database, Queensland Department of Natural Resources and Mines

2.2. Rating Periods

The risk assessment was carried out for three points in time (Figure 3):

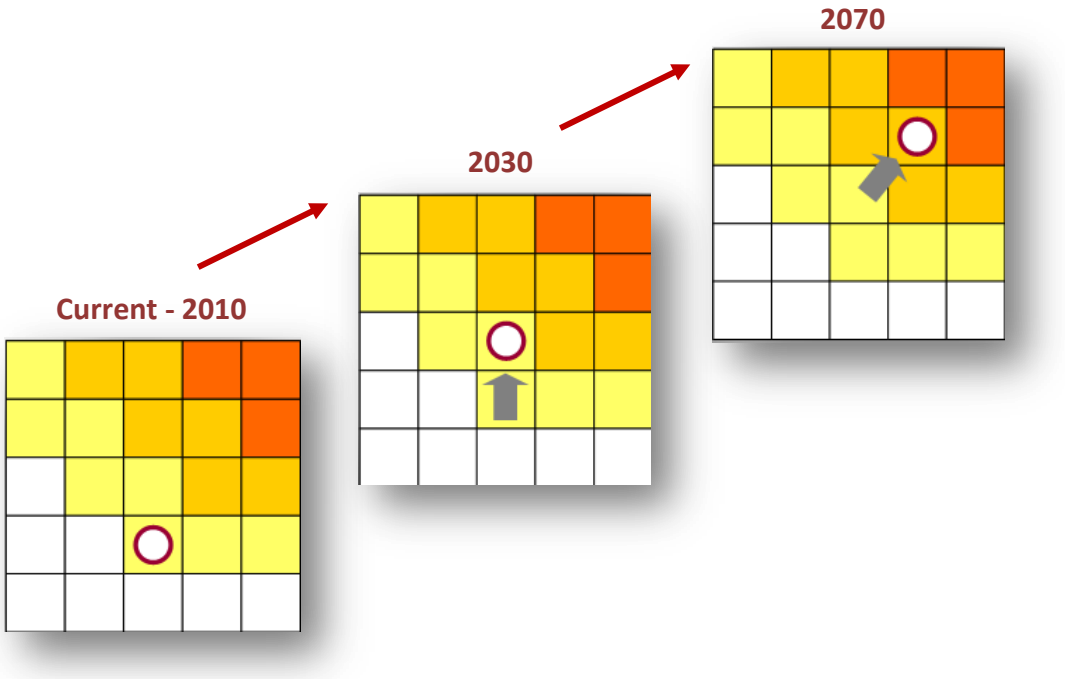
- Current, and extending through the life of the existing Corporate Plan (2010);
- Beyond this to 2030, when we have an initial projection of the changes that might arise; and
- Beyond 2030, using the 2070 projection as an indication of long term prospects.

It was important to consider that some risks that would not be likely to become serious until beyond 2030, or even towards 2070, might be affected substantially by Council's actions and decisions in the next few years.

In particular, this concerned land use planning and infrastructure asset management.

In other words, while the time scale of some of the risks may appear to be so long that they fall outside the scope of immediate planning processes, they might in future be seen to be linked to decisions made now.

Figure 3: Risk rating time periods



2.3. Key Elements

Key Elements and Risk Categories are a set of topics that allow a systematic approach to the risk identification and analysis steps of the process. Each topic is somewhat narrower than the entire assessment scope, allowing workshop attendees to focus their thoughts and go into more depth than they would if they tried to deal with everything in one go.

The Key Elements and Risk Categories that were used for the risk workshops are shown in Table 1. They provided a useful breakdown of RCC operations and services, and useful division of expertise.

Table 1: Workshop Structure and Key Elements

Workshop 1

(a) Infrastructure
- Asset Management
- Buildings
- Coastal Infrastructure
- Power
- Stormwater
- Transport
- Other ...

(b) Planning and development
- Commercial Planning
- Economic Development
- Industrial Planning
- Open Space Planning
- Residential Planning
- Strategic Planning
- Other ...

Workshop 2

(a) Environmental management
- Biodiversity and Catchments
- Bushfire Management
- Coastal Management
- Parks and Reserves
- Pests and Weeds
- Waste Management
- Wetlands and Creeks
- Other...

(b) Community and social planning
- Aged Care and Health
- Children's Health
- Emergency Services
- Public Health and Safety
- Recreation Services
- Other ...

(c) Corporate services
- Legal and Financial Services
- Workplace Health and Safety
- Other ...

2.4. Climate Change and Policy Scenarios

The climate change and policy scenarios that were used throughout the risk assessment are given in Appendix 2 (page 103).

The climate change scenarios provide a summary of the climate changes and associated impacts that the City of Redland is likely to face. The scenarios are not intended to be exhaustive, but give an indication of the types of climate changes and impacts that might be anticipated. The scenarios draw on the draft biophysical and socio-economic impacts reports that were collected prior to the workshops.

The policy scenarios reflect judgements as to the most likely direction and (where feasible) magnitude of changes in policies relevant to RCC's operations; drawing on currently available information about federal and state government policies.

The scenarios are presented for two time periods:

- Short term (i.e. within the next 5 years); and
- Medium term (to 2030).

It was not feasible to consider additional policy directions beyond 2030.

2.5. Objectives and Success Criteria

Redland City Council's strategic priorities are contained within the Corporate Plan 2006-2010. In brief, Council is focussed on the following:

- *Natural Environment*: Ensure the enhancement of biodiversity including koala habitat, bushland, green-space, waterways, catchments, air and coastal ecosystems in recognition of our unique location on Moreton Bay.
- *Land Use*: Preserve a balance with urban, rural, bushland, village, coastal and island character of the Redlands by managing growth.
- *Essential Services*: Provide and maintain water, waste services, roads, drainage and support the provision of transport and waterways infrastructure.
- *Community Health and Wellbeing*: Build safe, strong and self reliant communities with access to community services, infrastructure and opportunities for participation in community life.
- *Economic Prosperity*: Enhance employment participation and the community's standard of living through encouraging economic development opportunities.
- *Governance*: To provide a clear organisational direction supported by effective leadership and a framework of policies, plans and strategies that are responsive to the community's needs and which promote accountable and ethical standards of practice.
- *Corporate Services*: Support the organisation's capacity to deliver services to the community by building a skilled, motivated and continually learning workforce, ensuring our assets and finances are well managed, our corporate knowledge is captured and used to best advantage, and that we market and communicate our services effectively.

These priorities were used as a guide in identifying and analysing the risks associated with climate change.

2.6. Scales for Consequences, Likelihoods and Risk

Three scales were used for the risk assessment:

- A scale to describe the level of consequence of a risk if it should happen;
- A scale to describe the likelihood of suffering that level of consequence; and
- A scale to assign a priority rating to each risk, given its consequences and likelihood.

Redland City Council has published a high-level *Risk Management Framework*, as well as the more operational *Risk Assessment Handbook*. The *Handbook* includes scales for consequences and likelihood, and a matrix for risk evaluation.

We adopted the evaluation framework as written, with a minor addition to the likelihood scale so as to include risks that are not expected to recur. This is in keeping with the *AGO Guide*. By adopting the RCC evaluation framework we ensure that the climate change risks and priorities we obtain from the exercise can be maintained within Council's existing risk register and plans for monitoring and review.

The RCC likelihood scale is given in Table 2. The risk evaluation matrix is in Table 3. Table 4 overleaf shows the consequence scale.

These scales were applied under two key assumptions:

- We rated the consequences associate with each risk only once, and referred to this single rating when estimating likelihoods for each of the three rating periods. If the consequences associated with a particular risk had been thought to change markedly over time, then a new risk for each subsequent rating period would have been instantiated. That said, none of the identified risks fell into this category.
- We identified the controls associated with each risk, and considered the effect of such controls when assigning a likelihood to each rating period.

Threats and Opportunities

We note that AS/NZS4360 defines risk in terms that allow for both desirable and undesirable outcomes of uncertainty; sometimes termed 'opportunities' and 'threats'. It is clear that some of the effects of climate change may lead to some new opportunities, and that RCC will wish to anticipate and exploit these as well as preparing to deal with the threats.

For this reason, we sought to identify opportunities as we discussed each key element and offered to record them in our spreadsheet. The consequences of opportunities were to be assessed using the same consequences scale, but with the direction of effect reversed — on the principle that a potential gain indentified but not taken is effectively the same as a loss.

This notwithstanding, no climate change opportunities were specifically identified, as evidenced by the risk register in Appendix 1 (page 99).

Key Assumptions

The evaluation of consequences and likelihoods rested on the following key assumptions:

- That current controls for each risk have been taken into account and that therefore the risk level describes additional risk resulting from climate change. i.e. Additional management and works by Council required on top of that currently being conducted in 2007.
- That consequence (cost) is assumed to remain constant over time. This assumption states that potential variations in the severity of the cause of the risk, over time, (and other potential influences on annual cost) have not been factored into the consequence assessment process. For example, that Council will not need to spend more money per annum for mosquito control in 2070 than in 2030.
- That the 'Current day', '2030' and '2070' likelihood assessments are based on Council not implementing any additional controls over time. However, where possible, external control factors have been factored in. For example, Council not providing additional money but receiving expected State government assistance to respond to a climate change risk.
- That where Council efforts or other events result in a permanent solution to requirements for climate change controls by the given date 2030 or 2070, the likelihood is 'completed', and the risk becomes zero.

Table 2: Likelihood Rating Scale

Rating	Recurrent risks	Single events
Almost certain	Several times a year	More likely than not Probability greater than 50%
Likely	1-3 years	As likely as not 50/50 chance
Possible	3-6 years	Less likely than not but still appreciable Less than 50% chance but still quite high
Unlikely	6-10 years	Unlikely but not negligible Probability low but noticeably greater than zero
Rare	Beyond 10 years	Negligible Probability very small, close to zero

Table 3: Risk Evaluation Scale

Likelihood	**Consequences**				
	Insignificant	Low	Medium	Major	Catastrophic
Almost certain	H-40	H-48	E-72	E-84	E-100
Likely	M-24	H-44	H-56	E-80	E-96
Possible	L-12	M-28	H-52	E-76	E-92
Unlikely	L-8	L-20	M-36	H-64	E-88
Rare	L-4	L-16	M-32	H-60	H-68

Table 4: Consequence Assessment Scale

Strategic	Operational	Activity	Priority	Consequences
> $250,000 CMC, State Government and EPA involvement	> $250,000 CMC, State Government and EPA involvement	>$50,000 CMC, State Government and EPA involvement	Catastrophic	*Financial:* Significant long term impact. Organisation operation change required *Loss of life*: Fatalities have occurred *Injury/Illness*: Significant injury/illness has occurred requiring hospitalisation and ongoing treatment *Environmental*: Significant environmental impact with long term effects *Building/Assets*: Services disrupted. Significant loss of assets requiring relocation of staff *Governance*: Significant number of public queries to be dealt with. Planned media releases and other media coverage as required updating the public on the event. Initiate part or the entire BCP recovery plan.
$100,001-$250,000 CMC, State Government and EPA involvement	$100,001-$250,000 CMC, State Government and EPA involvement	$20,001–$50,000 CMC, State Government and EPA involvement	Major	*Financial*: Long term financial impact *Loss of life*: A fatality *Injury/Illness*: Serious Injury/illness and hospitalisation has occurred. Some ongoing treatment required *Environmental*: Medium to long term damage requiring immediate intervention *Building/Assets*: Services disrupted *Governance*: Planned response to public detailing events and response. ELG and Council updated Management intervention required. Full report to Council.
$50,001 - $100,000 State Government and EPA advised	$10,001-$100,000 State Government and EPA advised	$5,001-$20,000 State Government and EPA advised	Medium	*Financial*: Some financial redirection required medium impact *Loss of life*: Nil *Injury/Illness*: Minor injury with no hospitalisation required. No long term effects *Environmental*: Minor damage short term effect *Building/Assets*: Damage occurred. Short term impact *Governance*: Public concern dealt with as queries arrive. Councillors notified through report Report required to Council although matter handled during normal business operation.
$20,000-$50,000 EPA advised matter handled internally	$5,000-$10,000 EPA advised matter handled internally	$3,000-$5,000 EPA advised matter handled internally	Low	*Financial:* Low financial impact. Absorbed in normal business operation *Loss of life*: Nil *Injury/Illness*: Medical attention required *Environmental*: Matter handled as a part of normal business operation *Building/Assets*: Minor damage does not impact on normal business *Governance:* Required to address minor public concern Incident can be handled within normal business.
<$20,000 EPA advised matter handled internally	<$5,000 EPA advised matter handled internally	<$3,000	Insignificant	*Financial:* Insignificant financial impact. Absorbed in normal business operation *Loss of life*: Nil *Injury/Illness*: No medical attention required *Environmental*: Matter handled as a part of normal business operation *Building/Assets*: No damage *Governance:* Incident can be handled within normal business.

3. Results

3.1. Results in Brief

3.1.1. Priorities

Forty-eight (48) risks were identified against the five Key Elements and 31 Risk Categories shown in Table 1. A further risk — *Significant escalation of the distribution of acid sulphate soils* — was raised and flagged as an important issue for RCC, but was not rated pending further assessment (page 54).

A summary of risk ratings by Key Element is given in Figure 2.

Most striking is the fact that no climate change risks were rated Extreme over any of the three time periods. As mentioned previously, the risks were assessed using the RCC scales and matrix to ensure that this assessment sits comfortably within the RCC corporate register.

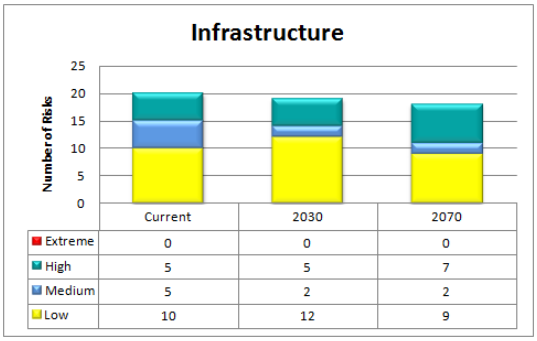
Next to the absence of any Extreme risks, the most striking characteristic of the risks is that the Medium and High risks are almost all associated with Infrastructure. This dominance is clearest with short term risks but also seen in the medium and long term assessments.

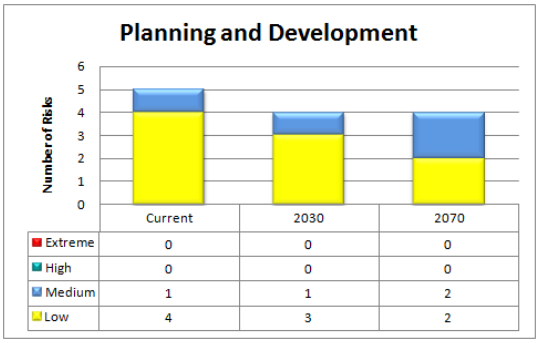
One of the two liability risks to risks to Corporate Services — threat of flooding or sea level rise described on page 66 — also warrants mention. This risk was not only ranked High for all three time periods, but was also the second highest rated of all of the climate change risks identified (Table 5).

A substantial number of risks to environmental management were identified, but tended to be rated Low in the short-medium term. Two of these risks moved to a rating of High in the long term, and three more were rated Medium, but the ratings were lower across the board than might have been expected at the start of the assessment. Further detail about the approach to rating risks to environmental management is given on page 42.

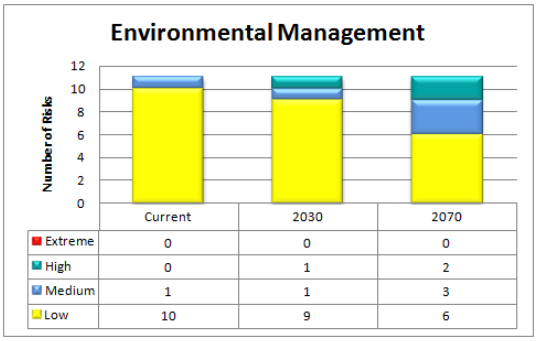
Figure 4: Summary of Risks and Priorities by Key Element

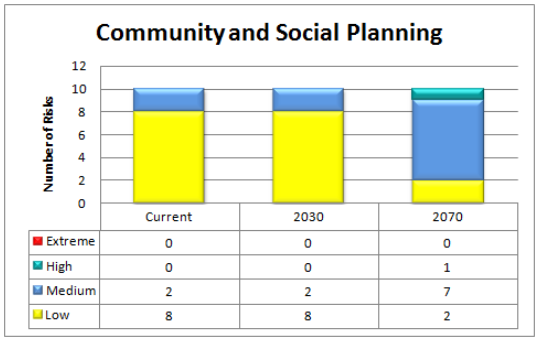
Workshop 1





Workshop 2





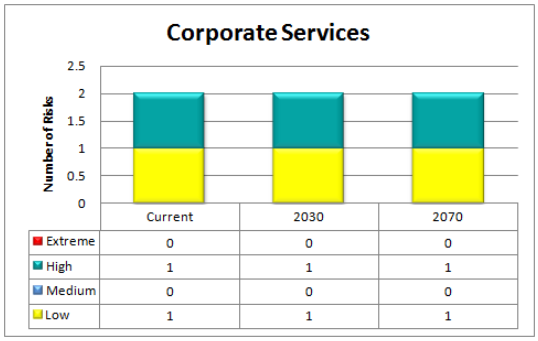


Table 5 through to Table 7 provide a numerical ranking of High and Medium priority risks for the current-2010 period, the medium term (2030) and the longer term (2070), respectively. The balance of the Low priority risks are not shown here, but can be viewed in the complete risk register in Appendix 1 (page 99).

The tables illustrate the observation made above, that infrastructure risks tended to dominate the High priority bracket across all three time periods. Indeed, all but one of the risks rated High in the short term fell within the infrastructure Key Element. This result is not surprising given that a decision was made at the start of the process to focus this assessment on consequences specifically accrued to RCC — that is, that community-level values were not included. Had this decision not been taken, it is conceivable that some risks to public health and the environment (in particular) might have received higher rankings.

Table 5: Medium and High Short-Term Risks

Key Element	Risk Category	Risk Name	Priority (current)
Infrastructure	Coastal Infrastructure	Increased damage to pontoons, marina, jetties, piles through storm tide	64
Corporate Services	Legal and Financial Services	Council liability for developments threatened by flooding or sea level	60
Infrastructure	Transport	Barge inoperable in rough weather	56
Infrastructure	Coastal Infrastructure	Low-lying public infrastructure damaged by flooding	44
Infrastructure	Stormwater	Infiltration of sewerage through illegal connections to stormwater	44
Infrastructure	Transport	Ferry inoperable in rough weather	44
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	36
Community and Social Planning	Public Health and Safety	Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	32
Community and Social Planning	Recreation Services	Sporting or recreational areas threatened through lack of water	28
Infrastructure	Buildings	Council buildings (coastal) damaged through wind, hail or flooding	28
Infrastructure	Coastal Infrastructure	Increased damage to sea walls (armouring) through storm tide	28
Infrastructure	Other	Closed landfills inundated through storm surge	28
Infrastructure	Stormwater	Stormwater treatment systems overwhelmed	28
Planning and Development	Strategic Planning	Increased need for shaded/cool facilities	28
Infrastructure	Buildings	Building fittings and retrofits required to accommodate temperature increases and storms	24

Table 6: Medium and High Medium-Term Risks (2030)

Key Element	Risk Category	Risk Name	Priority (2030)
Infrastructure	Coastal Infrastructure	Increased damage to pontoons, marina, jetties, piles through storm tide	64
Corporate Services	Legal and Financial Services	Council liability for developments threatened by flooding or sea level	60
Infrastructure	Transport	Barge inoperable in rough weather	56

Key Element	Risk Category	Risk Name	Priority (2030)
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	52
Infrastructure	Coastal Infrastructure	Low-lying public infrastructure damaged by flooding	44
Infrastructure	Stormwater	Stormwater treatment systems overwhelmed	44
Infrastructure	Transport	Ferry inoperable in rough weather	44
Community and Social Planning	Public Health and Safety	Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	32
Community and Social Planning	Recreation Services	Sporting or recreational areas threatened through lack of water	28
Environment	Coastal Management	Significantly increased algal blooms (Lyngbya majuscula)	28
Infrastructure	Buildings	Council buildings (coastal) damaged through wind, hail or flooding	28
Infrastructure	Coastal Infrastructure	Increased damage to sea walls (armouring) through storm tide	28
Planning and Development	Strategic Planning	Inadequate planning for the impact of water stress, drought, storms and temperature on agricultural (poultry) and horticultural (flower farming and others) industries	28

Table 7: Medium and High Long-Term Risks (2070)

Key Element	Risk Category	Risk Name	Priority (2070)
Corporate Services	Legal and Financial Services	Council liability for developments threatened by flooding or sea level	60
Infrastructure	Coastal Infrastructure	Increased damage to pontoons, marina, jetties, piles through storm tide	60
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	56
Infrastructure	Transport	Barge inoperable in rough weather	56
Community and Social Planning	Public Health and Safety	Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	52
Infrastructure	Coastal Infrastructure	Low-lying public infrastructure damaged by flooding	48
Infrastructure	Stormwater	Stormwater treatment systems overwhelmed	48

Key Element	Risk Category	Risk Name	Priority (2070)
Infrastructure	Transport	Ferry inoperable in rough weather	48
Environment	Coastal Management	Significantly increased algal blooms (Lyngbya majuscula)	44
Infrastructure	Buildings	Council buildings (coastal) damaged through wind, hail or flooding	44
Infrastructure	Coastal Infrastructure	Increased damage to sea walls (armouring) through storm tide	44
Community and Social Planning	Aged Care and Health	Anxiety (mental health and general wellbeing) about climate change - particularly elderly	28
Community and Social Planning	Aged Care and Health	Increased need for home-assisted and respite care and associated funding, as a result of temperature changes and storms	28
Community and Social Planning	Emergency Services	Demand for emergency services increased through increased storms and flooding	28
Community and Social Planning	Public Health and Safety	Harm to lifestyle and general wellbeing as a result of increased midge or mosquito density	28
Community and Social Planning	Public Health and Safety	Public safety threatened through increased storms or flooding	28
Community and Social Planning	Recreation Services	Recreation areas threatened by coastal inundation	28
Community and Social Planning	Recreation Services	Sporting or recreational areas threatened through lack of water	28
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through coastal inundation	28
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through persistent water stress	28
Environment	Bushfire Management	Significant harm to animal or plant species and ecosystem health through bushfires	28
Planning and Development	Strategic Planning	Inadequate planning for the impact of water restrictions, transport difficulties, rising temperatures and increased storm activity on tourism	28
Planning and Development	Strategic Planning	Insufficient coastal open space as a result of rising sea level and coastal inundation	28
Infrastructure	Stormwater	Stormwater drains blocked through reduced average rainfall or drought	24
Infrastructure	Stormwater	Stormwater drains overwhelmed by intense rainfall	24

3.1.2. Trends

Table 8 (overleaf) ranks risks according to the magnitude of change in their numerical ratings across the three time periods. The final three risks in the table decreased over time, and have a negative difference rating. Risks that did not change are not shown in this table.

Interpretation of risk difference is complex, but in most cases reflects: (a) the relative sensitivity of RCC to climate variables in the areas concerned combined with the relative increase of consequences or likelihood as climate change becomes more marked; and (b) the relative extent to which existing controls would mitigate these changes.

Many of the risks that change most over time relate to issues over which RCC has little or no scope for adaptive control over-and-above that already at work. The risks associated with algal blooms or burgeoning mosquito populations provide good examples of this. While existing controls are generally sufficient, both issues are likely to be sensitive to climate change and both are likely to become substantially more difficult for RCC to manage without a specific adaptation plan (risk treatment).

Although zero-change risks were left out of the table (for brevity), they are also instructive in the sense that they represent situations where adaptive controls are likely to able to keep pace with changes in climate stressors. A typical example of this is damage to RCC buildings, where the combination of adaptive insurance and an evolving building code mean that the consequences and likelihood of building damage will remain relatively constant over time.

Some risks are similar or the same in the short and medium term but rise dramatically in the longer term. These may be particularly important to include in the adaptation component of the project. They tend to represent situations where controls cease to compensate for climate change or where a threshold in background tolerance is likely to be breached.

Table 8: Difference in Risk Priority Ratings (2070-Current)

Key Element	Risk Category	Risk Name	Priority (Current)	Priority (2030)	Priority (2070)	Difference
Infrastructure	Buildings	Building fittings and retrofits required to accommodate temperature increases and storms	24	4		
Infrastructure	Stormwater	Infiltration of sewerage through illegal connections to stormwater	44			
Planning and Development	Strategic Planning	Increased need for shaded/cool facilities	28			
Environment	Coastal Management	Significantly increased algal blooms (Lyngbya majuscula)	20	28	44	24
Community and Social Planning	Public Health and Safety	Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	32	32	52	20
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	36	52	56	20
Infrastructure	Stormwater	Stormwater treatment systems overwhelmed	28	44	48	20
Infrastructure	Buildings	Council buildings (coastal) damaged through wind, hail or flooding	28	28	44	16
Infrastructure	Coastal Infrastructure	Increased damage to sea walls (armouring) through storm tide	28	28	44	16
Community and Social Planning	Aged Care and Health	Anxiety (mental health and general wellbeing) about climate change - particularly elderly	16	20	28	12
Community and Social Planning	Aged Care and Health	Increased need for home-assisted and respite care and associated funding, as a result of temperature changes and storms	16	20	28	12
Community and Social Planning	Emergency Services	Demand for emergency services increased through increased storms and flooding	16	20	28	12
Community and Social Planning	Public Health and Safety	Harm to lifestyle and general wellbeing as a result of increased midge or mosquito density	16	20	28	12

Key Element	Risk Category	Risk Name	Priority (Current)	Priority (2030)	Priority (2070)	Difference
Community and Social Planning	Public Health and Safety	Public safety threatened through increased storms or flooding	16	20	28	12
Community and Social Planning	Recreation Services	Recreation areas threatened by coastal inundation	16	20	28	12
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through coastal inundation	16	20	28	12
Environment	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through persistent water stress	16	20	28	12
Environment	Bushfire Management	Significant harm to animal or plant species and ecosystem health through bushfires	16	20	28	12
Infrastructure	Stormwater	Stormwater drains blocked through reduced average rainfall or drought	12	12	24	12
Infrastructure	Stormwater	Stormwater drains overwhelmed by intense rainfall	12	12	24	12
Planning and Development	Strategic Planning	Inadequate planning for the impact of water restrictions, transport difficulties, rising temperatures and increased storm activity on tourism	16	20	28	12
Planning and Development	Strategic Planning	Insufficient coastal open space as a result of rising sea level and coastal inundation	16	20	28	12
Community and Social Planning	Emergency Services	Demand for recovery services increased through increased storms and flooding	4	8	12	8
Environment	Biodiversity and Catchments	Significant harm to aquatic animal or plant populations or ecosystem health through ocean acidification	4	8	12	8
Infrastructure	Other	Damage to microwave linkage to isolated and island communities	4	8	12	8
Community and Social Planning	Aged Care and Health	Increased incidence of heat stress through increased peak temperatures and heat waves	4	4	8	4
Environment	Coastal	Significant degradation of beaches and foreshores through coastal	16	20	20	4

Key Element	Risk Category	Risk Name	Priority (Current)	Priority (2030)	Priority (2070)	Difference
	Management	inundation				
Environment	Other	Increased incidence and severity of landslide through intense rainfall	4	4	8	4
Environment	Pests and Weeds	Increased pests and weeds through altered temperature and rainfall parameters	4	8	8	4
Environment	Wetlands and Rivers	Degradation of riverine ecosystems through reduced stream flow	4	4	8	4
Environment	Wetlands and Rivers	Significantly increased pollution of waterways through storms and flooding	4	4	8	4
Infrastructure	Coastal Infrastructure	Low-lying public infrastructure damaged by flooding	44	44	48	4
Infrastructure	Transport	Ferry inoperable in rough weather	44	44	48	4
Planning and Development	Strategic Planning	Inadequate planning for the impact of rising sea level on marine industries	4	4	8	4
Infrastructure	Coastal Infrastructure	Increased damage to caravan parks through storm activity	20	20	16	-4
Infrastructure	Coastal Infrastructure	Increased damage to pontoons, marina, jetties, piles through storm tide	64	64	60	-4
Planning and Development	Strategic Planning	Inadequate planning for the impact of water stress, drought, storms and temperature on agricultural (poultry) and horticultural (flower farming and others) industries	20	28	16	-4
Infrastructure	Other	Closed landfills inundated through storm surge	28	20	20	-8

3.2. Risks for Infrastructure

3.2.1. Asset Management

No risks specifically addressing asset management were identified.

3.2.2. Buildings

Four risks to council buildings were identified and rated.

(a) Council buildings damaged through subsidence and shifting foundations with increased intense rainfall

Causes*:*	Increased 24-hour rainfall intensity. More frequent periods of intense rainfall, and local flash or creek flooding.			
Consequences:	Insignificant.[1]			
Controls:	Building Code of Australia and Building Act (1975). Redland Planning Scheme (2006). Hazard overlays. Ongoing scheduled building maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Rare
	Risk	Low (4)	Low (4)	Low (4)
Discussion:	On balance, a Low risk across all time periods. The rating reflects the supposition that subsidence is only likely to be significant for isolated aged structures located on particular soil types – for example, the amenities facility at Amity Point. Most workshop participants felt that the footings of most substantial RCC buildings would not be affected by increased rainfall intensity. There was, however, some resistance from a minority who claimed that subsidence in some other parts of SE QLD had been a significant issue.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC buildings. Include attributes for			

[1] Note that throughout this assessment, a single consequence score was continued for each of the three time periods

	the significance or the cost of each structure, its age and its stage in the cycle in building life and replacement. - Obtain spatial data for soil types in the City of Redland. - Correlate the location and attributes of RCC buildings with soil types to determine the assets most exposed to subsidence and the consequences of increased risk of subsidence as a result of climate change.

(b) Council buildings (inland) damaged through wind, hail or flooding

Causes*:*	Increased incidence and severity of storm activity, including high winds, hail and flooding.			
Consequences:	Low.			
Controls:	Building Code of Australia and Building Act (1975). Redland Planning Scheme (2006). Hazard overlays. Ongoing scheduled building maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Unlikely	Unlikely
	Risk	Low (20)	Low (20)	Low (20)
Discussion:	On balance, a Low risk across all time periods. This rating reflects several key points: - Location – this risk is specific to the relatively less exposed (i.e. inland) parts of the City. - Insurance – all RCC buildings are insured against damage from wind, rain, hail, flooding and lightning strikes. - Building codes – most substantial RCC buildings are relatively new, and will have been constructed according to a building code that is current or relatively unchanged from the current code. This code ensures that construction is robust to current extremes of wind, rain, hail, flooding and lightning strikes. As climate changes and extremes worsen, the building code will be updated and new buildings will be constructed appropriately. Climate projections suggest that even long term projections for Redlands are likely to include a frequency or intensity of extreme weather events beyond that which could be engineered against. - Impact of building damage – given building insurance, the more			

	significant impact of building damage concerns disruption of the delivery of normal RCC services. This could be substantial if substantial damage was sustained to a key building, such as the council chambers.
Spatial and other Analyses:	The fact that building insurance negates much of the cost to RCC associated with building damage through extreme weather events may mean that further assessment of this risk is not required. This notwithstanding, the following spatial assessment could be undertaken: - Obtain a spatial overlay of RCC buildings. Include attributes for the significance or the cost of each structure, its age and its stage in the cycle in building life and replacement. Select from this the RCC buildings that are not coastal. - Obtain spatial data (hazard overlay) for storm tides and flooding. This will be embellished through GEMS modelling. - Correlate the location and attributes of inland RCC buildings with storm tides and flooding to determine the assets most exposed and the consequences of increased risk of damage as a result of climate change.

(c) Council buildings (coastal) damaged through wind, hail or flooding

Causes:	Increased incidence and severity of storm activity, including wind, hail and flooding.			
Consequences:	Low.			
Controls:	Building Code of Australia and Building Act (1975). Redland Planning Scheme (2006). Hazard overlays. Ongoing scheduled building maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Possible	Likely
	Risk	Medium (28)	Medium (28)	High (44)
Discussion:	The exposure of coastal structures to greater wind speeds, storm intensities and flooding (flash, creek and storm tides) increased the likelihood ratings for this risk.			
Spatial and other Analyses:	As above the fact that building insurance negates much of the cost to RCC associated with building damage through extreme weather			

	events may mean that further assessment of this risk is not required. This notwithstanding, the following spatial assessment could be undertaken: - Obtain a spatial overlay of RCC buildings. Include attributes for the significance or the cost of each structure, its age and its stage in the cycle in building life and replacement. Select from this the RCC buildings that are coastal. - Obtain spatial data (hazard overlay) for storm tides and flooding. This will be embellished through GEMS modelling. - Correlate the location and attributes of coastal RCC buildings with storm tides and flooding to determine the assets most exposed and the consequences of increased risk of damage as a result of climate change.

(d) Building fittings and retrofits required to accommodate temperature increases and storms

Causes*:*	Increased peak temperatures, and increased incidence and severity of storms.			
Consequences:	Insignificant			
Controls:	Building Code of Australia and Building Act (1975). Redland Planning Scheme (2006). Hazard overlays. Ongoing scheduled building maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Likely	Rare	n/a
	Risk	Medium (24)	Low (4)	n/a
Discussion:	This risk was raised as a possibility, but rated downward largely on account of the relatively small numbers of buildings that would require significant retrofitting; over-and-above minor alterations through scheduled maintenance. In the long term (2070) the risk would disappear as RCC buildings were replaced or retrofits completed.			
Spatial and other Analyses:	None required.			

3.2.3. Coastal Infrastructure

Five risks to coastal infrastructure were identified and rated.

(a) Low-lying public infrastructure damaged by flooding

Causes:	Increased 24-hour rainfall intensity. More frequent periods of intense rainfall, and local flash or creek flooding.			
Consequences:	Low.			
Controls:	Construction standards. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Likely	Likely	Almost Certain
	Risk	High (44)	High (44)	High (48)
Discussion:	This risk encompassed all categories of low-lying infrastructure, including roads, bridges, footpaths, boardwalks, etc. RCC buildings are covered in a separate and specific risk (above). This infrastructure is damaged periodically during floods, and a scenario where this was exacerbated was seen to present a substantial cost to RCC.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC infrastructure. Include attributes for the significance or the cost of each item. Exclude RCC buildings (above), and focus instead on RCC roads, bridges, footpaths, boardwalks, etc. - Obtain spatial data (hazard overlay) for storm tides and flooding. This will be embellished through GEMS modelling. - Correlate the location and attributes of RCC infrastructure with storm tides and flooding to determine the assets most exposed; and the consequences of increased risk of damage as a result of climate change.			

(b) Increased damage to pontoons, marina, jetties, piles, etc, through storm tide

Causes:	Increased incidence and severity of storms, with increased storm surge and wave height and impact.

Consequences:	Major.			
Controls:	Marine construction standards. Ongoing RCC maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Unlikely	Rare
	Risk	High (64)	High (64)	High (60)
Discussion:	This was the most highly ranked of the climate change risks. The high ranking resulted largely from the inherent value of marine assets (pontoons, marina, jetties, piles, etc), and the high cost of replacement. Many of the structures are also significant or critical to RCC service delivery, or the day-to-day functioning of some island communities — including NSI. It was also noted that many of the structures are aging, and may have been built to less conservative specifications. The likelihood for this risk was lowered in the longer term as a result of the fact that most of the more critical structures will by then have been replaced – and replaced according to current marine construction specifications and current and future statistics about storm surge.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC marine infrastructure — pontoons, marina, jetties, piles, etc. Include attributes for the significance or the cost of each item, and its age or stage in the replacement cycle. Also include attributes for the sensitivity of each structure to storm tides and storm surges — for example, the height and tolerance of individual jetties. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of RCC infrastructure with storm tides and flooding to determine the assets most exposed and the consequences of increased risk of damage as a result of climate change.			

(c) Increased damage to sea walls (armouring) through storm tide

Causes:	Increased incidence and severity of storms, with increased storm surge and wave height and impact.
Consequences:	Low.

Controls:	Construction standards. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Possible	Likely
	Risk	Medium (28)	Medium (28)	High (44)
Discussion:	This risk was ranked relatively highly on account of the inherent cost of sea walls and other forms of marine armouring, and cost to RCC if/when these structures fail — whether through being overwhelmed by conditions beyond their specifications, or through damage.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC sea walls. Include attributes for the significance or the cost of each wall, and its age or stage in the replacement cycle. Also include attributes for the sensitivity of each structure to storm tides and storm surges — for example, the height and tolerance of individual walls. - Obtain spatial data for the infrastructure and communities exposed to damage when individual sea walls are overwhelmed or damaged. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of individual sea walls with storm tides and flooding to determine those most exposed and the consequences of increased risk of damage as a result of climate change.			

(d) Increased damage to caravan parks through storm activity

Causes:	Increased incidence and severity of storms, with increased storm surge and wave height and impact.			
Consequences:	Low.			
Controls:	Construction standards. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070

	Likelihood	Unlikely	Unlikely	Rare
	Risk	Low (20)	Low (20)	Low (16)
Discussion:	Some RCC caravan parks are already exposed to damage through storms and storm tides, and an exacerbation of this was seen likely to present a reasonably substantial cost to RCC (Low rating – which is substantial). The likelihood of damage was considered to fall in the longer term as individual parks were either reinforced or otherwise protected, or closed (as relevant) moved to less exposed sites.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC caravan parks. Include attributes for the size of each park, its importance to Redlands tourism, the extent an value of its amenities, etc. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of RCC caravan parks with storm tides and flooding to determine the parks most exposed and the consequences of increased risk of damage as a result of climate change.			

(e) Damage to footings or timber structures through ocean acidity

Causes*:*	Ocean acidification through climate change.			
Consequences:	Insignificant.			
Controls:	Construction standards – including requirements for cement and footings tolerance to acid sulphate soils.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Rare
	Risk	Low (4)	Low (4)	Low (4)
Discussion:	This risk was flagged as it is an issue that (apparently) has been raised in other countries or settings. That said, the marine footings in Redlands waters have been constructed to withstand the significantly greater acidification that can result from inundation of acid sulphate soils and are unlikely to be affected by the relatively minor acidification that might accompany climate change.			
Spatial and other Analyses:	None required.			

3.2.4. Power

Two risks to the RCC power supply were identified and rated.

(f) Loss of power as a result of overload

Causes*:*	Overload of RCC power supply or grid as a result of increased peak demand for cooling.			
Consequences:	Low.			
Controls:	On-site back-up generators, or access to back-up generators, for some key RCC facilities.			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Unlikely	Unlikely
	Risk	Low (20)	Low (20)	Low (20)
Discussion:	This risk was raised as power failure (largely as a result of damage to power infrastructure – see below) is occasionally an issue for RCC. Without quantitative modelling, it is difficult to estimate the likelihood of general power failure through an overload precipitated by use of air conditioners — that said, the situation was conceivable in the event of a serious heatwave.			
Spatial and other Analyses:	Spatial analysis is not required, although some identification of the buildings without in-house generators (or access points for the attachment of mobile generators) might help to quantify the extent to which RCC is exposed through power failure. Some additional assessment of the robustness of regional and local power infrastructure to increased demand (as might occur in a heatwave) would also be helpful.			

(g) Loss of power as a result of storms

Causes*:*	Increased incidence and severity of storm activity, including wind, hail and flooding			
Consequences:	Low.			
Controls:	On-site back-up generators, or access to back-up generators, for some key RCC facilities.			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Unlikely	Unlikely

	Risk	Low (20)	Low (20)	Low (20)
Discussion:	This risk was raised as power failure (largely as a result of damage to power infrastructure – see below) is occasionally an issue for RCC.			
Spatial and other Analyses:	Spatial analysis is not required, although some identification of the buildings without in-house generators (or access points for the attachment of mobile generators) might help to quantify the extent to which RCC is exposed through power failure.			

3.2.5. Stormwater

Four risks associated with stormwater infrastructure were identified and rated. Additional risks regarding (*inter alia*) the contamination of waterways were also raised, and are discussed under Environmental Management (page 42).

(a) Stormwater drains overwhelmed by intense rainfall

Causes*:*	Increased 24-hour rainfall intensity. More frequent periods of intense rainfall, and local flash or creek flooding.			
Consequences:	Insignificant.			
Controls:	Ongoing maintenance. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Possible	Likely
	Risk	Low (12)	Low (12)	Medium (24)
Discussion:	Stormwater reticulation is currently (consistently) overwhelmed as a result of intense rainfall activity. Brackish water can back up through the system, and can contaminate waterways or flood private or public land. RCC is frequently called to assist in response to minor damage to private property, or temporary flooding.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - A spatial overlay of RCC stormwater reticulation system has been provided. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have also been provided. - Prepare an assessment methodology that correlates spatial			

	predictors for exposure to flooding as a result of stormwater with assets at risk – RCC assets, as well as community and commercial assets. Ground truth the assessment methodology with observed impacts of stormwater backwash. - Use the assessment methodology to better estimate the extent of likely harm to RCC as a result of stormwater backwash and flooding.

(b) Stormwater drains blocked through reduced average rainfall or drought

Causes*:*	Altered distribution of rainfall to give longer dry periods. Increased frequency and severity of drought.			
Consequences:	Insignificant.			
Controls:	Ongoing maintenance. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Possible	Likely
	Risk	Low (12)	Low (12)	Medium (24)
Discussion:	With prolonged dry periods, leaf litter and other material can accumulate in stormwater reticulation and lead to partial or complete blockages. These can then result in backwash of stormwater and local flooding. The outcomes are very similar to those associated with overwhelming stormwater reticulation.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - A spatial overlay of RCC stormwater reticulation system has been provided. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have also been provided. - Prepare an assessment methodology that correlates spatial predictors for exposure to flooding as a result of stormwater with assets at risk – RCC assets, as well as community and commercial assets. Ground truth the assessment methodology with observed impacts of stormwater backwash. - Use the assessment methodology to better estimate the extent of likely harm to RCC as a result of stormwater backwash and flooding.			

(c) Stormwater treatment systems overwhelmed

Causes*:*	Increased 24-hour rainfall intensity. More frequent periods of intense rainfall, and local flash or creek flooding.			
Consequences:	Low.			
Controls:	Ongoing maintenance of non-biological filtration measures. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Likely	Almost Certain
	Risk	Medium (28)	High (44)	High (48)
Discussion:	This risk specifically addressed the issue of overwhelming stormwater treatment systems – both non-biological (coarse and finer filtration arrangements) and biological (largely wetlands). The overwhelming of stormwater treat has implications both for the environment and community (as regards pollution) and for the treatment systems themselves — inasmuch as the wetlands are considered environmental assets, and can be damaged by contaminants and sustained flooding.			
Spatial and other Analyses:	Spatial assessment is not required. It might, however, be helpful to document and describe the range of stormwater treatment systems and to systematically assess the sensitivity of each to stormwater overload. From this, a more searching assessment of the direct and indirect impacts of treatment overload on RCC could be made.			

(d) Infiltration of sewerage through illegal connections to stormwater

Causes*:*	Increased 24-hour rainfall intensity. More frequent periods of intense rainfall, and local flash or creek flooding.			
Consequences:	Low			
Controls:	Ongoing identification and closure of illegal connections.			
Ratings:		Current	2030	2070

	Likelihood	Likely	n/a	n/a
	Risk	High (44)	n/a	n/a
Discussion:	This risk addressed the situation where the many illegal connections between residential sewerage outlets and the stormwater reticulation system — and periods of intense rainfall — combine to result in backwash of contaminated stormwater. This situation is being addressed by RCC. The problem will continue, but will become an issue for RWW in 2010 and this out of scope in the medium and longer terms.			
Spatial and other Analyses:	None required.			

3.2.6. Transport

Three risks associated with stormwater infrastructure were identified and rated.

(a) Road damage through drought

Causes:	Increased frequency and severity of drought.			
Consequences:	Insignificant.			
Controls:	Construction standards. Ongoing road maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Rare
	Risk	Low (4)	Low (4)	Low (4)
Discussion:	This risk was identified as a possibility, as it has been an issue for some QLD councils in the periods of intense rain that followed the millennium drought. Roads surfaces can be made fragile by prolonged dry periods, and more susceptible to damage through flooding. The issue has not been observed by RCC, however, and was not considered to be a risk of any substantial likelihood or consequences — even in the face of increased likelihood of droughts and intense rainfall.			
Spatial and other Analyses:	None required.			

(b) Barge inoperable in rough weather

Causes:	Increased frequency and severity of storms.			
Consequences:	Medium.			
Controls:	Able to use the (more ocean-robust) ferry for maintenance of some critical services.			
Ratings:		Current	2030	2070
	Likelihood	Likely	Likely	Likely
	Risk	High (56)	High (56)	High (56)
Discussion:	The NSI barge is vulnerable to storms and high seas, and is not sued in these conditions. The barge transports waste from NSI, and is required for some other RCC and community support services. The ferry is considered more robust to seas and storms, and can be substituted to a limited extent. The ferry, however, is also inoperable in serious storms (below). RCC considered that an increased frequency and severity of storms might result in exposure of the NSI community to reduced services, with ramification for Council and the community.			
Spatial and other Analyses:	Although spatial analysis is not required, an assessment of the number of days that the NSI barge is inoperable — and the extent to which the ferry can be substituted — would be helpful. This assessment could be extended (as relevant) to any other barged services that might operate on other islands or inaccessible coastal communities in the City.			

(c) Ferry inoperable in rough weather

Causes:	Increased frequency and severity of storms.			
Consequences:	Low.			
Controls:	None identified.			
Ratings:		Current	2030	2070
	Likelihood	Likely	Likely	Likely
	Risk	High (44)	High (44)	High (44)
Discussion:	The NSI ferry is largely a passenger transport vessel, and is considered more robust to high swells than the barge (above). The			

	ferry is, however, used to a limited extent in place of the barge to transport waste and enable some other community services to the island to be maintained.
Spatial and other Analyses:	Although spatial analysis is not required, an assessment of the number of days that the NSI ferry is inoperable would be helpful. This assessment could be extended (as relevant) to any other ferry services that might operate on other islands or inaccessible coastal communities in the City.

3.2.7. Other …

Two further uncategorised risks for infrastructure were identified and rated.

(a) Closed landfills inundated through storm surge

Causes:	Increased incidence and severity of storms, with increased storm surge and wave height and impact.			
Consequences:	Low.			
Controls:	None identified.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Unlikely	Unlikely
	Risk	Medium (28)	Low (20)	Low (20)
Discussion:	Some closed landfills in mangrove areas are continuously exposed to storm surge and tide, and could in time be disturbed. These landfills are in all cases protected by sea walls, but such walls are breached by storm tides. A raised sea level, and an increase in the frequency and severity of storms, could threaten the integrity of some sea walls (above).			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain spatial data for closed landfills. - Obtain spatial data for Shire zones and key RCC, community, commercial and environmental assets. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the exposed landfills of with storm tides and flooding to determine those most exposed to inundation - Correlate exposed landfills with Shire zones and assets to determine the extent to which such exposure might impact on			

	RCC.

(b) Damage to microwave linkage to isolated and island communities

Causes:	Increased frequency and severity of storms — principally wind and lightening.			
Consequences:	Insignificant.			
Controls:	Ongoing maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (4)	Low (8)	Low (12)
Discussion:	Microwave links are used to connect some of the more isolated parts of the City. Microwave links are also used extensively by RWW. Currently, microwave linkages fail for approximately 3 hours each quarter. This risk considered the impact that an increase in the frequency and severity of storms might have on RCC as a result of disconnection of communities dependent on microwave linkages or on RWW. The issue, whilst important to maintain on the register, was not considered substantial as the direct impacts are minor and short-lived and are not accrued directly to RCC.			
Spatial and other Analyses:	None required.			

3.3. Risks for Planning and Development

Risk categories and draft risks were created for Commercial Planning, Economic Development, Industrial Planning, Open Space Planning, Residential Planning, Strategic Planning and 'other' Planning. However, only Strategic Planning was retained at the close of the workshop. In truth, most risks identified under the Planning and Development Key Element could rationally be classified in any one of several different categories, and restriction of risks to the category of Strategic Planning was seen as a pragmatic abbreviation of terminology rather than a scaling back of important issues.

Within Strategic Planning, five risks were identified and rated.

(a) Increased need for shaded/cool facilities

Causes:	Increased number of extremely hot days and increased peak temperatures.

Consequences:	Low.			
Controls:	Urban plans and planning strategies. Redland Planning Scheme (2006).			
Ratings:		Current	2030	2070
	Likelihood	Possible	n/a	n/a
	Risk	Medium (28)	n/a	n/a
Discussion:	RCC has already committed substantial funds toward the creation of increased shade in streetscapes, car parks, parks and gardens and other parts of the City. This risk addresses the scenario under which RCC is required to markedly increase shade creation as real and perceived impacts of climate change are felt in the City. RCC considers that sufficient shade will have been provided by 2010, after which this risk is negated.			
Spatial and other Analyses:	None required.			

(b) Insufficient coastal open space as a result of rising sea level and coastal inundation

Causes*:*	Rising sea level and coastal inundation.			
Consequences:	Low.			
Controls:	Coastal armaments. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the impact of coastal inundation on the open space buffer that currently separates the exposed coastline and its various ecosystems from residential and other land. This buffer serves an environmental purpose (page 42), but also protects residential and other developed property from the full impact of coastal weather and storm tides. The strategic risk is to fail to consider the need to maintain a buffer — in particular, in the more exposed parts of the coastline.			

Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.

(c) Inadequate planning for the impact of rising sea level on marine industries

Causes:	Rising sea level			
Consequences:	Insignificant.			
Controls:	Marine and building codes and standards. Coastal armaments. Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Unlikely
	Risk	Low (4)	Low (4)	Low (8)
Discussion:	This risk addressed the failure of RCC to consider the impact of rising sea level and storm tides on the various marine industries within the City. This principally concerns the exposure of fixed structures, such ramps and boathouses. The direct impact of climate change on marine structures is considered elsewhere (page 27).			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of marine industry infrastructure in the City. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of marine industry infrastructure with storm tides and flooding to determine the infrastructure most			

	exposed to rising sea levels and the consequences to RCC of failing to consider the impacts rising sea level on such infrastructure as a part of its strategic planning for the City.

(d) Inadequate planning for the impact of water restrictions, transport difficulties, rising temperatures and increased storm activity on tourism

Causes*:*	Water restrictions, transport difficulties, rising temperatures and increased storm activity.			
Consequences:	Low.			
Controls:	None specifically identified.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the failure of RCC to consider the impact that a range of adverse characteristics of climate change might have on the City's important tourism industry. It was recognised that some coastal parts of Australia that rely on tourism for economic stability feel threatened by the prospect of ongoing water restrictions, heat waves, more frequent storms, etc. It was also acknowledged, however, that: (a) the climate change scenarios are comparatively mild for Redlands; and (b) the proximity of the City to Brisbane and other significant Queensland centres (and its islands and other significant natural attractions) reduce the extent to which tourism is likely to be reduced.			
Spatial and other Analyses:	Spatial analysis is not required. Some more detailed analysis of the sensitivity of the key Redlands tourism industries to the impacts of climate change might, however, be helpful. This would include (*inter alia*) an assessment of the impact of the recent drought, storm cycles and other extreme weather events on visitor numbers and tourism revenue.			

(e) Inadequate planning for the impact of water stress, drought, storms and temperature on agricultural (poultry) and horticultural (principally flower-farming) industries

Causes*:*	Increased water stress, drought, storms and average and peak temperatures.
Consequences:	Low.

Controls:	None specifically identified.			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Possible	Rare
	Risk	Low (20)	Medium (28)	Low (16)
Discussion:	This risk was dismissed during the (first) Infrastructure and Planning workshop on the grounds that the Redlands were no more exposed to the impacts of climate change than other parts of Australia, and generally more resilient to water stress. The agriculture industry in the Redlands is now concentrated on poultry farming and horticulture. The poultry industry relies on its proximity to grains crops, and a relatively constant temperatures. The robustness of grains supply to the Redlands was not examined, but temperature is unlikely to alter to the extent that it would threaten poultry farming. The horticulture industry relies heavily on water. This was not thought to be a difficulty during the Infrastructure and Planning workshop. Participants at the subsequent workshop felt, however, that changes in the water arrangements for Redlands and other parts of SE QLD would threaten the viability of some horticulture industries — in particular, the flower farming industry. They also felt that the poultry industry may be at risk from threat to the stability of Redlands' climate or from grains prices or shortages. The ratings were altered to reflect these more conservative judgements, but further analysis is required to confirm the priority of this risk.			
Spatial and other Analyses:	Spatial analysis is not required. As mentioned above, further analysis is required to determine the sensitivity of the Redlands poultry industry to likely changes in climate key parameters. The robustness of the regional grains industry should also be examined, as should opportunities for alternative sources of poultry feed. The exposure of the horticulture industry to water shortages in the past and future (with new water arrangements) is a separate issue, and should be examined. With these issues clarified, the ratings for this risk might be altered substantially.			

3.4. Risks for Environmental Management

Some difficulty was encountered when estimating the impact of climate change on RCC for Environment Management risks.

It was noted that, whilst the RCC consequence scale included an environmental descriptor, this was a liability based measure intended to be used for issues such the impact of sewage or waste spills or waste on parks and gardens — it was not intended to be used to assess the 'value' of the natural environment to RCC. It was also noted that if such values were permitted during the assessment of risks to environmental management, then similar values should be used to represent the value of 'community wellbeing' and 'health and wellbeing of individuals', etc. To some extent, biodiversity risks, described in the next section capture concerns about maintaining the natural environment.

As it was the policy throughout this assessment to restrict consequence assessment to the specific impacts of climate change on RCC, some of the environmental management issues were rated lower than might have been expected.

3.4.1. Biodiversity and Catchments

Six risks to biodiversity and catchments were identified and rated. From these four risks were distilled.

We note that whilst 'animal and plant populations' was considered separately from 'habitat', the risk ratings were identical. Thus we have combined the two, preserving both 'populations' and 'habitat' in the risk names and addressing controls and other issues conjointly. These changes have also been carried through to the final project spreadsheet.

(a) Significant harm to animal or plant populations, habitat or ecosystem health through coastal inundation

Causes:	Sea level rise and coastal inundation.			
Consequences:	Low.			
Controls:	Coastal armaments. Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 14: Current extent and status of regional ecosystems (C) - SOE Indicator 15: Change in extent of remnant vegetation (regional ecosystems)(P) - SOE Indicator 19: Number, status and extent of 'listed' native plant species (C) - SOE Indicator 23: Number, status and extent of 'listed' native animal species (C)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible

	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the impact of coastal inundation on the environmental elements of the open space buffer that currently separates the exposed coastline and its various ecosystems from residential and other land. This buffer protects residential and other developed property from the full impact of coastal weather and storm tides, but it also provides a critical environment niche for shore birds and other wildlife.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. - Obtain attribute data for the environmental values of coastal open space buffers throughout the City. This should include a list of animal and (as relevant) plant populations, and a metric describing their sensitivity or intrinsic value to ecosystem health and biodiversity. Regional ecosystems should also be included. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.			

(b) Significant harm to animal or plant populations, habitat or ecosystem health through persistent water stress

Causes*:*	Reduced average rainfall or drought.
Consequences:	Low.
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 14: Current extent and status of regional ecosystems (C) - SOE Indicator 15: Change in extent of remnant vegetation (regional ecosystems)(P) - SOE Indicator 19: Number, status and extent of 'listed' native

	plant species (C) - SOE Indicator 23: Number, status and extent of 'listed' native animal species (C)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	Reduced rainfall or drought have the potential to impact on more regional ecosystems than does coastal inundation; which has a very specific effect. Many of the threatened Redlands ecosystems are quite small and isolated, and are thus less robust to events such as drought or bushfire. Once substantially harmed, it is an extremely difficult and long-term exercise to rejuvenate them – something that is generally only attempted under the resources and contractual obligations of the mining and resources sector. Koala habitat, in particular, is a concern to Redlands and is a very significant priority for the City.			
Spatial and other Analyses:	Spatial analysis may not be needed here as the regional ecosystems have been mapped and are well documented understood by RCC. It might, however, be helpful to assess the drought-sensitivity of each regional ecosystem against its inherent value to the City. It might also be helpful to further enunciate the RCC response to water stress (if any) and to further explore other issues associated with the impact of water stressed ecosystems on RCC — specifically.			

(c) Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding

Causes:	Increased incidence and severity of storm activity, including wind, hail and flooding.
Consequences:	Medium.
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 14: Current extent and status of regional ecosystems (C) - SOE Indicator 15: Change in extent of remnant vegetation (regional ecosystems)(P) - SOE Indicator 19: Number, status and extent of 'listed' native

	plant species (C) - SOE Indicator 23: Number, status and extent of 'listed' native animal species (C)			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Possible	Likely
	Risk	Medium (36)	High (52)	High (56)
Discussion:	Storms were considered a more significant threat to fragile regional ecosystems than either inundation or persistent water stress.			
Spatial and other Analyses:	Spatial analysis may not be needed here as the regional ecosystems have been mapped and are well documented understood by RCC. It might, however, be helpful to assess the storm-sensitivity of each regional ecosystem against its inherent value to the City. It might also be helpful to further enunciate the RCC response to storms (if any) and to further explore other issues associated with the impact of storm-damaged ecosystems on RCC — specifically.			

(d) Significant harm to aquatic animal or plant populations or ecosystem health through ocean acidification

Causes:	Progressive ocean acidification.			
Consequences:	Insignificant.			
Controls:	None specifically identified.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (4)	Low (8)	Low (12)
Discussion:	This risk relates to the background impact that global ocean acidification may have on aquatic ecosystems within Redlands waters. It was noted that very small change in pH will affect the shells of crustaceans, oysters and other molluscs. The impact on turtles, dugongs and other marine life is not known. Coral may be bleached to a greater extent than would occur under warming of the ocean alone. The flow-on effects of this (if any) on tourism are not known.			
Spatial and other Analyses:	Spatial analysis is not required. It would , however, be valuable to carry out some desktop research into the likely impacts of climate change on key aquatic ecosystems.			

	This might take the form of a minor desktop review, as much of this work will have been summarised in Australian and overseas literature. A correlation of key findings with the more significant aquatic communities in Redlands waters could then be undertaken and this reviewed.

3.4.2. Bushfire Management

A single generic risk relating to bushfire management was identified and rated. Issues of RCC liability (as relating to bushfires) are discussed under Corporate Services (page 66).

(a) Significant harm to animal or plant populations, habitat or ecosystem health through bushfires

Causes:	Increased incidence of extreme and high bushfire weather, and reduced autumn and winter rainfall.			
Consequences:	Low.			
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 29: Extent, location and number of bushfires (C)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	It was noted that climate change might have two different effects on the risks to RCC associated with bushfires. Firstly, the number of high and extreme fire danger days is likely to increase. Secondly, rainfall pattern is likely to shift toward more intense summer falls, with drier autumn and winter. This may result in an increase in the build up of desiccated bushfire fuel, and an increased potential for ignition and increased fire intensity. Bushfires are a natural part of many Australian ecosystem cycles of growth rejuvenation. This notwithstanding, such ecosystems are usually larger and better able to rejuvenate than some of the small or fragmented regional ecosystems in the City. It was also noted that some of the regional ecosystems have particular value to the overall biodiversity of the City.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain the bushfire hazard overlay.			

	- Obtain an overlay of regional ecosystems within the City. This should include a list of animal and (as relevant) plant populations, and a metric describing their sensitivity or intrinsic value to ecosystem health and biodiversity. - Correlate the location of regional ecosystems and their inherent value with bushfire hazard to determine the parts of the City where bushfire risk is most likely to be substantial and the consequences to RCC of increased bushfire risk.

3.4.3. Coastal Management

Two risks to coastal management were identified and rated.

(a) Significant degradation of beaches and foreshores through coastal inundation

Causes:	Sea level rise and coastal inundation.			
Consequences:	Low.			
Controls:	Coastal armaments. Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 14: Current extent and status of regional ecosystems (C)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Unlikely
	Risk	Low (16)	Low (20)	Low (20)
Discussion:	This risk addressed the impact of coastal inundation on beaches and foreshores. The risk might, on review, be combined with the previously discussed risks associated with loss of the coastal open space buffer, and harm to foreshore ecosystems. That said, it was the intent in this risk to document the specific value of beaches, and the impact that harm to Redlands beaches might have on RCC. Key issues include the number and location of beaches most exposed to coastal inundation and storm tides (principally NSI, including Amity Point, Flinders Beach and Main Beach) and jurisdiction for issues related to beach integrity. It was noted that EPA has overarching responsibility, with state funds providing for one half of the maintenance costs. RCC responsible for day-to-day maintenance issues.			

Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City, with attribute data that differentiates between beaches and other forms of coastal habitat. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space data with storm tides and flooding to determine the parts of the City where encroachment on beaches is most likely to be substantial, and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.

(b) Significantly increased algal blooms (*Lyngbya majuscula*)

Causes:	Multi-factorial problem, but in general facilitated by rising levels of pollutants and warmer temperatures. Many blooms arise in deeper waters outside the City, and are carried into Shire waters with wind or currents.			
Consequences:	Low.			
Controls:	Ongoing RCC algal inspections and response. State of the Environment (SOE) reporting, including: - SOE Indicator 7: Ambient quality of surface water compared to guidelines (C) - SOE Indicator 9: Presence and extent of algal blooms (C)			
Ratings:		Current	2030	2070
	Likelihood	Unlikely	Possible	Likely
	Risk	Low (20)	Medium (28)	High (44)
Discussion:	Algal blooms occur in fresh and salt waters and under optimum conditions, many species of algae may grow rapidly to produce nuisance population levels. They are a highly visible indicator that waters are contaminated, usually with high levels of nutrients such as phosphorus and nitrogen. Algal blooms result in significant changes to ecology, may be hazardous to human health, increase the cost of supplying clean drinking water and can be nuisance when algae fouls boat propellers, rots on the high tide line along beaches, or makes swimming unpleasant.			

	The impact of algal blooms on RCC include the cost of cleanup, advisory communications (pamphlets, etc) and warning signs. Failure to adequately clean up has health implications. There is not currently any contributory state or Commonwealth funding for the management of algal blooms, the cost of which is in the order of $40-50,000 / season. This cost may increase when bloom residue can no longer be sent to Redlands landfills, and needs to be transported to Ipswich. The concern at RCC is for: (a) an increase in the frequency of blooms; and (b) extension of blooms to mangrove areas where clean up would be substantially more difficult and expensive. The costs of vacuum cleaning mangrove areas would be likely to lie in the realm of several hundred thousand dollars.
Spatial and other Analyses:	No spatial analysis is required. It might, however, be valuable to assess more systematically and quantitatively the extent of the threat to RCC, should algal blooms become more common or spread to involve mangrove areas.

3.4.4. Parks and Reserves

No risks to environmental management were specifically identified for 'parks and reserves', although both were considered throughout this and other Key Elements.

3.4.5. Pests and Weeds

A single pest and weed risk was identified and rated.

(a) Increased pests and weeds through altered temperature and rainfall parameters

Causes:	Altered rainfall patterns, increased droughts and increased incidence and severity of storms.			
Consequences:	Insignificant.			
Controls:	Ongoing RCC weed and pest control programs. State of the Environment (SOE) reporting, including: - SOE Indicator 20: Number, status and extent of pest plants (P). - SOE Indicator 24: Number, status and extent of pest animals (P).			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Unlikely
	Risk	Low (4)	Low (4)	Low (8)

Discussion:	Damage to natural systems caused by altered rainfall distribution, prolonged dry periods and droughts and storm events could result in greater prevalence of pests and weeds, and the introduction of some new species. This notwithstanding, it was reasoned that climate change (within any of the three assessed time periods) was unlikely to establishment or spread of new species significantly worse than those that are currently dealt with as a part of routine RCC business and operation.
Spatial and other Analyses:	None required.

3.4.6. Waste Management

No risks to environmental management were specifically identified for 'waste management', although this was considered within the discussion of NSI barge inoperability (page 36).

3.4.7. Wetlands and Creeks

Two risks to wetlands and creeks identified and rated.

(a) Significantly increased pollution of waterways through storms and flooding

Causes:	Increased incidence and severity of storms and heavy rainfall.
Consequences:	Insignificant.
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 7: Ambient quality of surface water compared to guidelines (C) - SOE Indicator 8: Ecosystem health rating for surface water (C) - SOE Indicator 9: Presence and extent of algal blooms (C) - SOE Indicator 10: Discharge of wastes and pollutants to surface waters (P) - SOE Indicator 11: Waterways covered by effective planning and management (R) - SOE Indicator 12: Effective planning and management of stormwater (R) - SOE Indicator 13: Changes to flow regimes of surface waters and

	groundwater (P)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Unlikely
	Risk	Low (4)	Low (4)	Low (8)
Discussion:	This risk addressed the increased frequency and amount of contaminants being transported to waterways with sediment during intense storms – including from Council waste management sites. The increased stormwater volumes from impervious catchments carry increased pollutant loads including sediment, nutrients, heavy metals, pesticides and bacteria to local waterways, wetlands and, in coastal areas, directly into Moreton Bay. Ambient water quality monitoring measures several aspects of water that are considered to give a reasonable indication of the condition of the water in a waterway or wetland. The measurable water quality indicator values when assessed against guideline values provide an indicative assessment of the state of water quality in comparison to environmental values. The indicators measured by ambient monitoring include: filterable reactive phosphorus, total phosphorus, ammonia nitrogen, nitrogen oxides, total nitrogen, chlorophyll-a, temperature, dissolved oxygen, pH, conductivity, turbidity. The importance of this issue notwithstanding, it was reasoned that an increase in contamination could be managed largely through existing controls and would not constitute a risk to RCC of any substance. This was reflected in both the consequences and likelihood scores.			
Spatial and other Analyses:	None required.			

(a) Degradation of creek ecosystems through reduced stream flow

Causes:	Reduced average annual rainfall and increased evapo-transpiration.
Consequences:	Insignificant.
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 7: Ambient quality of surface water compared to guidelines (C)

<table>
<tr><td></td><td colspan="4">- SOE Indicator 8: Ecosystem health rating for surface water (C)
- SOE Indicator 9: Presence and extent of algal blooms (C)
- SOE Indicator 10: Discharge of wastes and pollutants to surface waters (P)
- SOE Indicator 11: Waterways covered by effective planning and management (R)
- SOE Indicator 12: Effective planning and management of stormwater (R)
- SOE Indicator 13: Changes to flow regimes of surface waters and groundwater (P)</td></tr>
<tr><td rowspan="3">Ratings:</td><td></td><td>Current</td><td>2030</td><td>2070</td></tr>
<tr><td>Likelihood</td><td>Rare</td><td>Rare</td><td>Unlikely</td></tr>
<tr><td>Risk</td><td>Low (4)</td><td>Low (4)</td><td>Low (8)</td></tr>
<tr><td>Discussion:</td><td colspan="4">Flows of surface water are diverted for drinking water, agriculture and other rural uses, industry and to allow urban development. Diversion of water affects environmental flows, which are critical for maintaining the health of the waters and creeks on which ecosystems and industries depend. The timing, quantity and duration of flows and the quality of water are linked and depend on interactions between the catchment, floodplain, wetland, ground water and streams.
The importance of this issue notwithstanding, it was reasoned that the impact of creek degradation on RCC would not be substantial. This was reflected in both the consequences and likelihood scores.</td></tr>
<tr><td>Spatial and other Analyses:</td><td colspan="4">None required.</td></tr>
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3.4.8. Other…

Two risks to environmental management in the category of 'other' were identified. Of these, one was rated and one was put 'on-watch' as an issue that requires some further assessment.

(a) Increased incidence and severity of landslide through intense rainfall

Causes:	Increased incidence of intense rainfall.
Consequences:	Insignificant.
Controls:	Redland Planning Scheme (2006).

	Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Unlikely
	Risk	Low (4)	Low (4)	Low (8)
Discussion:	A *Redland Landslide Hazard Assessment* for the Redlands was conducted by SMEC Australia Pty Ltd for Council in 2005. This review of topography, geology, geomorphology and hydrological conditions suggest that given the generally low lying terrain the occurrence of landslides is relatively minor and mainly confined to: - The steeper slopes in the Naranleigh-Fernvale geological formation, overlain by colluvium, around the Mount Cotton range - The steeper slopes within the basalt flows that occupy the coastal areas near Wellington Point, Cleveland, Victoria Point and Redland Bay - The steeper slopes of North Stradbroke Island, in particular where there is little vegetation cover Collectively, the additional impact climate change on landslide hazard in the City was not rated as substantial.			
Spatial and other Analyses:	The landslide hazard overlay provides a spatial rating of this hazard across the City.			

(b) Significant escalation of the distribution of acid sulphate soils

Causes*:*	Rising sea level and progressive inundation of flood prone land.			
Consequences:	n/a			
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 30: Extent of acid sulphate soils (C) - SOE Indicator 31: Extent of storm tides, flood prone and drainage constrained land (C)			
Ratings:		Current	2030	2070
	Likelihood	n/a	n/a	n/a
	Risk	n/a	n/a	n/a

Discussion:	This risk described exacerbation of the development of acid-sulphate soils to the point that this seriously impacts on land use, the security of building footings, aquatic and other ecosystems, etc. Acid sulphate soils occur naturally over extensive low-lying coastal areas. These soils form when sea or brackish water mixes with sediments containing organic matter and are part of the world's natural sulphur cycle. The acid sulphate soils of most concern are those formed within the past 10,000 years, during and after the last major sea level rise. Sulphate in sea water reacts with iron oxides in sediments in the presence of organic matter from mangroves and other coastal vegetation. This chemical reaction produces large quantities of iron sulphides, mostly iron pyrite, in the sediments. When exposed to air, particularly atmospheric oxygen, sulphides can oxidise to sulphuric acid, hence the name acid sulphate soils. There are two types of acid sulphate soils, actual and potential. Actual acid sulphate soils (AASS) occur in naturally low-lying coastal areas below 5 m Australian Height Datum (AHD). Potential acid sulphate soils (PASS) lie above this level and become a problem when exposed to oxygen as a result of excavation work or some other form of soil disturbance. Because potential acid sulphate soil areas are waterlogged, they are often drained. Drainage and excavation of these areas can lead to the rapid release of large quantities of acid water into estuarine streams. Exposure to oxygen causes potential acid sulphate soils to generate acid runoff that affects waterways and results in fish kills and harm to the natural environment. Acid sulphate soils can affect building footings and special construction techniques or treatments are required. The best management of potential acid sulphate soils is to avoid disturbance.
Spatial and other Analyses:	The acid sulphate soils overlay provides a spatial rating for this hazard across the City. Further analysis of the extent to which the acid sulphate soils issue confronting RCC might be affected by climate change (principally, sea level rise and coastal inundation), would enable this risk to be re-assessed and rated.

3.5. Risks for Community and Social Planning

3.5.1. Aged Care and Health

Three risks to aged care were identified and rated.

(a) Anxiety (mental health and general wellbeing) about climate change; particularly elderly

Causes:	Various.			
Consequences:	Low.			
Controls:	Ongoing RCC community support services and communication. State of the Environment (SOE) reporting, including: - SOE Indicator 43: Aging of the population (P)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	Redlands aged population is increasing at the highest rate in Queensland. This risk addressed the likelihood of increased community anxiety about climate change, and loss of wellbeing; especially within vulnerable groups such as the elderly. RCC is involved in local health and fitness programs at an on-ground level, even though these are largely organised by State. If mental health issues from climate change proved to be significant, RCC would become involved. RCC offers Home Assist Secure to elderly to stay in their homes. Demand for services may increase with anxiety about temperatures or storm activity. Current the program is funded by Dept of Housing and Disability Qld to $400/person. RCC then administers the program, including maintenance of the panel of providers, database, etc. In due course, RCC may be required to add to the funds provided by State Govt, or otherwise seek additional funding. Short-term, this is not a significant issue as RCC has never reached the capacity of State funding.			
Spatial and other Analyses:	None required.			

(b) Increased incidence of heat stress through increased peak temperatures and heat waves

Causes:	Increased average and peak temperatures.

Consequences:	Insignificant.			
Controls:	Ongoing RCC community support services and communication. State of the Environment (SOE) reporting, including: - SOE Indicator 43: Aging of the population (P)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Unlikely
	Risk	Low (4)	Low (4)	Low (8)
Discussion:	Heat waves put vulnerable sections of the community at risk from dehydration and heat stress, especially the elderly. Exposure to prolonged ambient heat promotes various physiological changes, including cramping, heart attack and stroke. People most likely to be affected are those with chronic disease (e.g. cardiovascular disease, type 2 diabetes) and hence are older people as a group, due to their higher burden of chronic disease. The ability to cool by sweating also decreases with age as the threshold temperature at which sweating commences increases. A key determinant of heat stress is the rate of change between temperature extremes. Another is the threshold at which power infrastructure might conceivably become overloaded by the use of air conditioners.			
Spatial and other Analyses:	None required.			

(c) Increased need for home-assisted and respite care and associated funding, as a result of temperature changes and storms

Causes:	Increased average and peak temperatures, and increased frequency of severe storms.			
Consequences:	Low.			
Controls:	Ongoing Home Assist and respite care programs. State of the Environment (SOE) reporting, including: - SOE Indicator 43: Aging of the population (P)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible

	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the situation where increased peak temperatures or increased storm activity substantially increased the need for Home Assist services or respite care. RCC offers Home Assist Secure to elderly to stay in their homes. Demand for services may increase with anxiety about temperatures or storm activity. Current the program is funded by Dept of Housing and Disability Qld to $400/person. RCC then administers the program, including maintenance of the panel of providers, database, etc. RCC also offers respite care for persons unable to manage home living. This facility, whilst acknowledged, was not discussed in any depth. In due course, RCC may be required to add to the funds provided by State Govt or to seek additional Govt funding. Short-term, this is not a significant issue as RCC has never reached the capacity of State funding. In the longer term, increased peak temperatures and increased frequency o intense storms may mean that demand for Home Assist or respite care exceed the current allotment.			
Spatial and other Analyses:	Spatial analysis is not required. Some further analysis of this issue would however, enable the risk to be assessed more rigorously (probably quantitatively) and re-rated as required. In particular, it would be useful to assess the threshold at which demand for: (a) Home Assist; and (b) respite care would exceed fixed resources (e.g. carers or available beds) or funding. This could be correlated with historical data, to determine whether any previous periods of sustained high temperatures or violent weather have measurably altered the requirement for such services. Once obtained, this estimate could be correlated with the increase temperatures and frequency of severe storms that is likely to accompany climate change in the short, medium and longer term.			

3.5.2. Children's Health

No risks specifically addressing children's health were identified.

3.5.3. Emergency Services

Two risks to emergency services were identified and rated.

(a) Demand for emergency services increased through increased storms and flooding

Causes:	Increased incidence and severity of storm activity, including wind,

	hail and flooding.			
Consequences:	Low.			
Controls:	RCC and other disaster and emergency plans.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the issue of an increased demand for emergency services as a result of increased frequency and intensity of extreme weather. In general, RCC copes with demand for storm clean up and community assistance by channelling resources from other less critical areas – or from areas that cannot proceed on account of the prevailing weather (for example, parks and gardens maintenance crews). RCC performs this and other relief activities by following a fixed emergency response process. RCC is in principle assisted by SES units. This notwithstanding, it was noted that RCC employees dominate SES units, and that the additional manpower is not as marked as otherwise be the case. Emergency response was considered an issue that could be absorbed within routine council operations, up to the point of (for example) and extreme cyclonic storm or storm activity that persisted for a sustained period. In either case, damage to RCC asses, or the constant drain on RCC resources, would impact on council. This was evidenced several years ago (2005?) when a series of 3 severe storms occurred in rapid succession and placed a substantial demand on RCC services.			
Spatial and other Analyses:	None required.			

(b) Demand for recovery services increased through increased storms and flooding

Causes*:*	Increased incidence and severity of storm activity, including wind, hail and flooding.			
Consequences:	Insignificant.			
Controls:	RCC and other disaster and emergency plans.			
Ratings:		Current	2030	2070

	Likelihood	Rare	Unlikely	Possible
	Risk	Low (4)	Low (8)	Low (12)
Discussion:	This risk addressed the specific issue of demand for recovery services — with a focus on community support, rather than the physical services required to correct the damage caused by violent weather. It was noted that following prolonged or excessively destructive weather events (and other community-wide disasters) councils per se are best placed to support vulnerable sectors of the community. This role has been evidenced in the aftermath of severe storms and flooding in Victoria and north QLD. As the Redlands have not experienced extreme weather events or flooding of the sort experienced by Victoria and north QLD, recovery plans are not well-established. In the event of a community wide disaster in Redlands, this could result in significant disruption of RCC operations.			
Spatial and other Analyses:	Further review of the RCC disaster recovery plans — and the status of preparation and planning — would enable this risk to be re-assessed and re-rated.			

3.5.4. Public Health and Safety

Two risks to public health and safety were identified and rated.

(a) Public safety threatened through increased storms or flooding

Causes:	Increased incidence and severity of storm activity, including wind, hail and flooding.			
Consequences:	Low.			
Controls:	Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the situation where an increased incidence and severity of storms, and sea level rise, might contribute to an increased incidence of flash flooding and other storm-related threats			

	to public safety. This was not seen as an issue that was likely to directly impact on RCC to a substantial degree — notwithstanding the effect of climate change on the incidence of storms and flooding. This position was based on the division between storms and floods that cause property damage or disruption of services (and might be experienced more often in the City); and storms and floods that threaten lives (as experienced in some other parts of Australia).
Spatial and other Analyses:	No further analysis is necessarily needed, although some elaboration of the characteristics of extreme weather events that typical threaten lives might help to support this assessment. It would also be helpful to examine historical records, and determine whether lives have been lost in the City as a result of storms or flooding, and under what conditions. Esoteric deaths — such as drowning whilst playing in a stormwater drain — should not be included unless there is a clear link to future risk associated with the weather event concerned.

(b) Public safety threatened through altered incidence of mosquito-borne infectious diseases

Causes*:*	Altered temperatures and rainfall - altered vector distribution.			
Consequences:	Medium.			
Controls:	Ongoing RCC mosquito control programs. Ongoing State and Commonwealth arbovirus surveillance activities.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Possible
	Risk	Medium (32)	Medium (32)	High (52)
Discussion:	Key concerns are Dengue fever, Murray Valley encephalitis and Ross River fever. Some background on these diseases follows: ***Dengue fever*** *is transmitted by the urban freshwater mosquito Aedes aegypti. The geographic region suitable for Ae aegypti and dengue transmission is expected to move far south from its current position, as far as northern NSW by 2100. Dengue virus is not yet endemic in Australia. Dengue infection causes a fever, general body aches, and occasional minor bleeding. Dengue haemorrhagic fever is a life-threatening complication that can result from a second dengue infection with a different virus serotype to that which caused the primary infection. Epidemics of dengue appear to have recently*			

	become more regular in north Queensland, with 5 major epidemics and many smaller epidemics between 1992 and 2004. Distribution of Ae. aegypti is not the only concern. The 'Asian tiger' mosquito (Ae. albopictus) has been observed in far northern Australia. This mosquito is more cold tolerant than Ae. Aegypti, and if it becomes established it could be a more efficient vector in southern temperate regions. ***Ross River virus*** *(RRv) is an arbovirus that is widely distributed throughout Australia. It has also been reported in many Pacific island countries including Papua New Guinea, the Solomon Islands, American Samoa, Fiji, New Caledonia and the Cook Islands. The virus can cause epidemic polyarthritis, which consists of arthritic symptoms that persist for several months and can be severe and debilitating. In some people the disease has been reported to linger for years. Rising temperatures and changing rainfall patterns are likely to have significant impacts on the epidemiology of RRv disease. These impacts would vary by geographical area.* ***Murray Valley encephalitis*** *is a uniquely Australian pathogen, although closely related to West Nile virus. In nature, MVE virus survives in natural cycles involving birds (especially water birds) and some species of mosquito. Murray Valley encephalitis (MVE) virus occurs naturally throughout the northern half of Australia, Papua New Guinea and eastern Indonesia. MVEV can commonly infect humans without producing apparent disease (subclinical infection), or it may cause a comparatively mild disease with features such as fever, headache, nausea and vomiting. In a small percentage of all people infected, mild disease may be a prequel to disease progression and involvement of the central nervous system, causing meningitis, or in the worst scenario, encephalitis of variable severity. The primary mosquito vector during epidemics is Cx. annulirostris. Other mosquitoes such as Cx. australicus and some Ochlerotatus species may be involved in other aspects of MVEV ecology.* RCC has a Ross River virus cluster in Reedy Bay. This is quite a small cluster by state standards, but a significant issue for the local community. RCC spends approximately $700,000/year on the control of mosquitoes. The concern is that with an increase in summer rainfall, mosquito populations will also increase. The added concern is that sea level rise and the inundation of higher mudflats will result in increased mosquito habitat and further increase in populations. With current king tides, the cost of control increases by approximately $100,000. Under expanded habitat scenario, this might increase to $200-300,000 or beyond. The movement of Dengue fever to SE QLD would necessitate a completely different form of control activity. Dengue fever control is focussed on urban populations, with small teams assisting the

	community to minimise standing water. The cost of these measures to RCC is difficult to determine, as some funding or resources would be provided by the State government.
Spatial and other Analyses:	Further spatial and other desktop analysis of this issue would be helpful. In particular, spatial data for mosquito populations could be correlated with waterways, regional ecosystems and storm tide and flooding overlays to determine the extent to which mosquito habitat is likely to alter under each of the three temporal scenarios. It would also be helpful to obtain the costs to council and state associated with dengue fever control in affected parts of northern Australia. These desktop assessments would help to better understand the collective consequences to RCC for altered disease and mosquito distribution and density. At this more detailed level, however, the issues would be better separated with individual assessments for expanding mosquito distributions (further divided by species, as relevant), and for each of the three arbovirus diseases.

(c) Harm to lifestyle and general wellbeing as a result of altered midge or mosquito distribution and density

Causes:	Altered temperatures and rainfall - altered vector distribution.			
Consequences:	Low.			
Controls:	Ongoing RCC mosquito control programs.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk addressed the issue of the effect of an increased mosquito and midge density on lifestyle within the City, and the impact of this on RCC. There is no doubt that increased mosquito and midge populations could seriously impact on the outdoor lifestyle enjoyed by many (most) Shire residents. There could also be an impact on tourism. The consequences of this to RCC would be focussed largely on the increased cost of mosquito control. It was explained above that With current king tides, the cost of control increases by approximately $100,000. Under expanded habitat scenario, this might increase to $200-300,000 or beyond.			
Spatial and other	Further spatial and other desktop analysis of this issue would be			

Analyses:	helpful. In particular, spatial data for mosquito populations could be correlated with waterways, regional ecosystems and storm tide and flooding overlays to determine the extent to which mosquito habitat is likely to alter under each of the three temporal scenarios. These desktop assessments would help to better understand the collective consequences to RCC associated with altered mosquito distribution and density. At this more detailed level, however, the issues would be better separated with individual assessments for each of the major species of mosquito or midge. These assessments would include spatial correlations (as above) but would also include consideration of the relative impact of each species on lifestyle, and the costs and logistics of control.

3.5.5. Recreation Services

Two risks to recreation services were identified and rated.

(a) Sporting or recreational areas threatened through lack of water

Causes:	Reduced average rainfall or drought, raised average and peak temperatures and increased evapo-transpiration.			
Consequences:	Low.			
Controls:	Redland Planning Scheme (2006). Ongoing scheduled maintenance. RWW and RCC water management plans and policies. Ongoing research into drought-tolerant turf species.			
Ratings:		Current	2030	2070
	Likelihood	Possible	Possible	Possible
	Risk	Medium (28)	Medium (28)	Medium (28)
Discussion:	RCC holds responsibilities for most of the sporting facilities within the City — any impacts of climate change on these facilities will translate to a direct impact on RCC. In total, the value of these facilities is approximately $64million. Workshop participants were divided as to the impact of climate change on sporting facilities. One group noted that RCC facilities remained healthy on balance throughout the recent drought, and are generally considered some of the greenest and best maintained			

	in SE QLD. Another group noted the imminent changes to RWW arrangements and water policy, and the ramifications this is likely to have as regards water restrictions within the City.
Spatial and other Analyses:	No spatial analysis is required. Some further communication with RCC and minor desktop assessment would however be helpful in clarifying whether the exposure of RCC sporting facilities is likely to increase as a result of new water policies, and what this might mean to RCC in the light of more frequent droughts and dry periods and increased evapo-transpiration.

(b) Recreation areas threatened by coastal inundation

Causes:	Rising sea level and coastal inundation.			
Consequences:	Low.			
Controls:	Redland Planning Scheme (2006). Ongoing scheduled maintenance.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Unlikely	Possible
	Risk	Low (16)	Low (20)	Medium (28)
Discussion:	This risk specifically addressed the issue of progressive inundation of coastal recreation areas, and the impact this might have on RCC. The buffer action of coastal open space — and its importance from a biodiversity standpoint — have been (pages 44 and 48, respectively). Coastal inundation and storm tides were reasoned to have a slower and lesser impact on the integrity of coastal recreation areas as places for recreation, than they would have on the biodiversity of such places or their importance as buffers. This is because salt-tolerant grasses and other plants tend to have been planted (or otherwise grow on) such areas, and because their tolerance to sporadic inundation is much higher than the tolerance (or particular needs) nesting shore birds and the like.			
Spatial and other Analyses:	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS			

	modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial, and the consequences to RCC of failing to consider maintaining this open space as viable recreation asset as the coastal inundation progresses.

3.6. Risks for Corporate Services

Two risks were identified for Corporate Services – both fell within the category of Legal and Financial Services. The following additional risks associated with liability were raised in draft form for workshop discussion, but ruled off the register:

- Council liability for damage through inappropriate building codes or standards
  - Ruled out on account of the fact that such standards are set by within the Building Code of Australia, and are not the legal responsibility of RCC.
- Council liability for damage through acid-sulphate subsidence of foundations
  - Ruled out on account of the of the extensive spatial risk work that RCC have undertaken on acid sulphate soils as a part of the (ongoing) Redlands Planning Scheme.

(a) Council liability for property damage through bushfires

Causes:	Increased incidence of extreme and high bushfire weather, and reduced autumn and winter rainfall.			
Consequences:	Insignificant.			
Controls:	Redland Planning Scheme (2006). Hazard overlays. State of the Environment (SOE) reporting, including: - SOE Indicator 29: Extent, location and number of bushfires (C)			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Rare
	Risk	Low (4)	Low (4)	Low (4)
Discussion:	This risk describes legal liability that might arise as a result of the permission of (or inadequate restrictions on) residential or commercial developments in areas of high bushfire risk.			
Spatial and other	None required.			

Analyses:	

(b) Council liability for developments threatened by flooding or sea level rise

Causes*:*	Sea level rise and coastal inundation.			
Consequences:	Major.			
Controls:	Redland Planning Scheme (2006). Hazard overlays.			
Ratings:		Current	2030	2070
	Likelihood	Rare	Rare	Rare
	Risk	High (60)	High (60)	High (60)
Discussion:	This risk addressed the issue of litigation arising from the harm to approved developments (commercial or residential) as a result of rising sea level or inundation. Corporate Services personnel considered the likelihood of this event to be diminishingly small, but the consequences either major or (in one senior opinion) catastrophic. Concern was expressed as to the current lack of case law on this important issue. Land buy-back would be the preferred option, but the value of such land is likely to be subject to argument.			
Spatial and other Analyses:	Two forms of follow-up assessment would be worthwhile to better understand (and more definitively rate) this risk. - Review of the existing case law and legal instruments - Spatial assessment of the extent of possible exposure of coastal developments at each of the three time periods The review of case law and legal instruments is beyond or expertise, and might well be an activity that RCC could carry out in-house. The spatial assessment is discussed further – in brief: - Obtain a spatial overlay of coastal developments within the City, with attribute data that differentiates between residential and commercial developments and notes the date of approval. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal developments with storm tides and flooding to determine the developments where (at each time horizon) inundation is most likely to be a concern, and the date of approval and extent of exposure to litigation			

4. Preliminary Spatial and Other Assessments

The purpose of this preliminary and essentially 'qualitative'[2] assessment of spatial and other data is to investigate some of the key issues identified during the risk assessment workshop, and to provide some context for more detailed follow-up work (section 5) that Redlands may choose to undertake for key risks.

In general terms, spatial assessment can be used in two ways:

- To illustrate or analyse the magnitude and spatial distribution of an asset; and
- To illustrate or analyse the extent to which one or more spatially distributed stressors (principally sea level or depth of inundation) is likely to impact on that asset.

The City of Redland is fortunate in having an extensive and highly developed library of spatial data and existing spatial assessments (termed 'hazard overlays'). This includes a fine detail digital terrain model (DTM), which provides a 2m gridded representation of elevation across the City. The spatial datasets are used principally to inform the (similarly developed) Redland Planning Scheme, asset management and other core works and services. In addition, Council has access to a range of Australian topographical and other baseline datasets, as well as the Cardno Lawson Treloar (Cardno) storm tide modelling study for Redland and Logan City Councils. This storm tide modelling study considered inundation depth across the City, given 1:20, 1:50, 1:100, 1:1,000, and 1:10,000 year storm tides.

As a component of this climate change risk assessment and adaptation planning project, we have reviewed the Cardno work and are in the process of developing revised storm surge datasets for similar storm and flood return intervals. These revised datasets include adjustment for: (a) the more conservative assumptions upon which our model is based; and (b) the likely effect of climate change on sea level in 2030, 2070 and 2100. The revised datasets will have one of two broad implications in relation to estimates of coastal inundation discussed in the following sections:

- The extent of land subject to inundation and the depth of inundation is likely to significantly greater than indicated; or
- The return interval for land currently subject to storm tide inundation is likely to be significantly lower than indicated. For example, land currently subject to 1:100 storm tide inundation will be subject to more frequent inundation under revised estimates.

The revised datasets will be important if further quantitative spatial assessment is to be carried out (section 5). For this preliminary qualitative work, however, the Cardno storm surge modelling data will provide an adequate point of reference. Specifically, the dataset we have used to guide inference about spatial exposure of Council assets to inundation is the 1:100 year storm tide inundation depth, with adjustment for enhanced cyclonic intensity and frequency. This file can be identified in the Cardno dataset as:

RCC-Storm Tide Depth_100Y_GH.TAB

[2] We stress that whilst numbers are cited throughout this section, the intent is to communicate general trends and patterns — that is, the assessment is intended to be essentially qualitative.

We note that Cardno also provide a 'Planning' dataset for all ARIs and years, which includes the 0.3m freeboard, which is currently being used by Redlands for planning purposes.

A screen shot of the 'RCC-Storm Tide Depth_100Y_GH' dataset is given in Figure 5. The dataset was provided as a thematic raster layer. This thematic layer used 0.25m increments to grade inundation depth, with colours ranging from dark blue (least inundation) to dark orange or red (maximum inundation), as shown in Figure 5.

We extracted the inundation depth data from this raster layer, and inserted it into a 25mx25m grid file that could then be queried by MapInfo GIS. A screen shot of this grid layer is shown in the lower insert on Figure 5. Grids are helpful, as their area has meaning and their borders support a range of intuitive GIS queries. For example, it is a simple enough exercise to select all grids representing an inundation depth of 1.5 to 2m that intersect with a spatial object representing a foreshore reserve. The total area of the selected grids will the approximate the area of the reserve that is likely to be inundated to a depth of 1.5 to 2m. Much of this section of the report has been constructed from simple spatial queries of this sort.

Inundation depth categories were mentioned above. Whilst the 25mx25m gridded dataset includes the precise measurements for inundation depth that were provided by Cardno it has also been graded into 5 inundation depth categories:

Category 1: 0 to 0.5m

Category 2: 0.5 to 1m

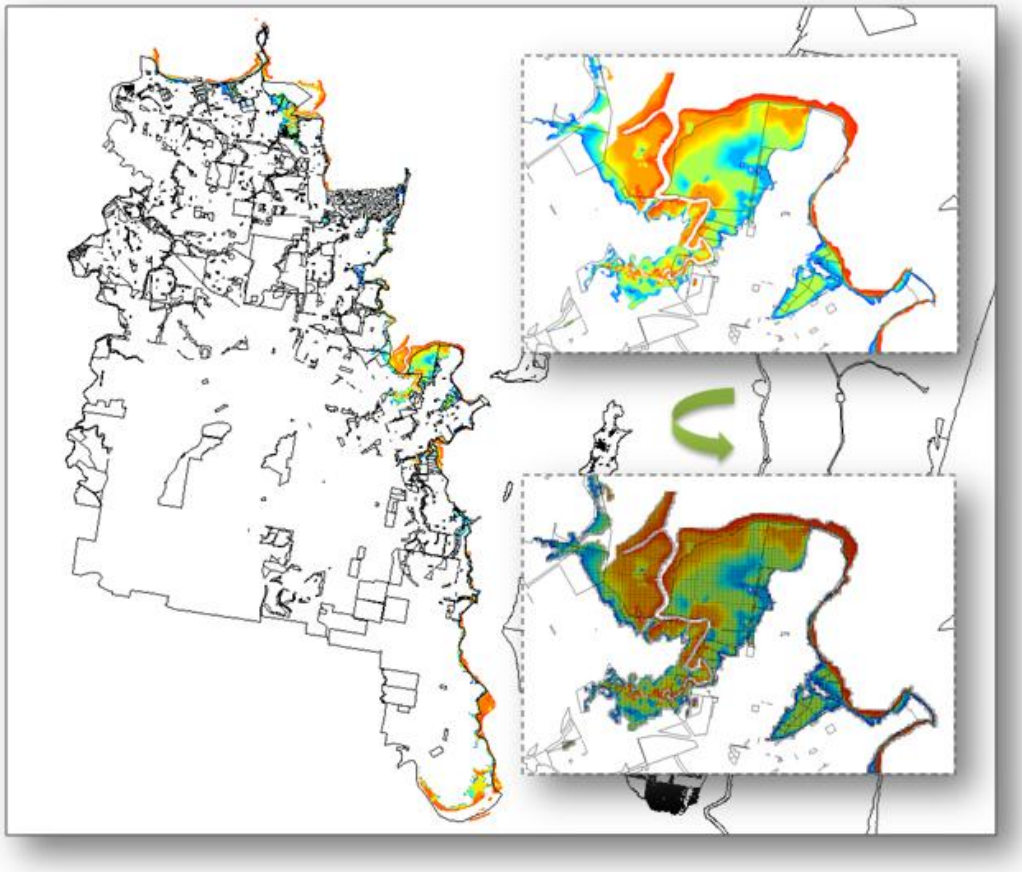
Category 3: 1 to 1.5m

Category 4: 1.5 to 2m

Category 5: greater than 2m

The five inundation depth categories have been used throughout this section of the report, as: (a) they provided a tractable solution for analysing the extent to which different forms of land or assets might be affected by storm surge; and (b) they reinforced the fact that this preliminary analysis (whilst necessarily numeric) was intended to be an essentially qualitative and superficial assessment.

Figure 5: RCC-Storm Tide Depth_100Y_GH dataset ad 25m gridded overlay



4.1. Issues for Infrastructure

Table 9 summarises the key issues for infrastructure, and correlates these with key climate stressors. The impact of drought on stormwater drains does not have a spatial determinant, and will not be dealt with further here. Likewise, while the impact of storms has a minor spatial determinant (coastal infrastructure is relatively more exposed) this will be difficult to assess with any reliability in a preliminary and essentially qualitative format.

This leaves us to examine spatial aspects of the impact of flood waters, storm surge and rising sea level, all of which are known to be strongly spatially dependent. With respect to assets, we were unable to locate spatial data for RCC buildings, footpaths, cycle ways, marine infrastructure or closed landfills, but were able to undertake some preliminary spatial analysis of land parcels, roads, power infrastructure and stormwater drains. For sea level correlations, we used the Cardno dataset (as above) and a RCC dataset that deals specifically with different categories of flood prone land.

Table 9: Key Issues for Infrastructure

Key Issues	Climate Stressor			
	Storms	Droughts	Flood Waters	Coastal Inundation
Council buildings	+++	-	++	+
Council roads, footpaths, cycle ways, etc	-	-	+++	+
Council marine infrastructure	+++	-	-	+++
Closed landfills	-	-	-	+++
Power infrastructure	+++	-	-	-
Stormwater drains	+++	+	+++	-
Ferry inoperability	+++	-	-	-

Key: +++ (major potential impact); ++ (moderate potential impact); + (minor potential impact)

Coastal Inundation

The impact of storm tide on land parcels in the Redlands Shire is summarised in Table 10. Here we found that 26 of the 8,827 land parcels in the Redlands cadastre (approx 0.4%) were on land projected to have an inundation depth of between 2 and 2.5m for a 1:100 storm tide. This number rose to a total of 340 parcels (approx 3.9%) when the depth of inundation was reduced to between 0.5 and 1m, which might be considered substantial inundation.

Across the City, this is quite a substantial proportion of land parcels. It is reasonable to assume that the further proportion of these parcels that include RCC buildings is at least as high, as a majority of such buildings are likely to be found in the lower lying and more intensely urbanised parts of the coastline. In other words: it is reasonable to presume that at least 6.4% of RCC buildings are currently on land that is likely to become substantially inundated. This is not necessarily problematic, as the Planning Scheme includes caveats for the construction of buildings on land that is known to be flood prone or prone to storm tide inundation – including a caveat that prohibits construction. That said, the statistic and its underlying distribution (Table 10 and parent GIS queries) will be useful to consider when discussing adaptation measures.

Similar trends are seen in the area of land subject to differing degrees of inundation, although it was clear that in Redlands the relatively larger land parcels tend to be situated in low-lying areas. This conclusion is based on the disparity between the percentage of land parcels in each inundation category, and the corresponding percentage of the cadastre that those parcels represent. For example, the 11.5% of all land parcels that are subject to some degree of inundation occupy 25.3% of the total area of the cadastre.

Importantly, this discussion has been restricted to cadastral area. The 25.3% of the total cadastre that is likely to be subject to some degree of inundation represents approximately 5.18% of the total area of the Redlands shire (51,737 ha).

Table 10: Coastal inundation and the Redlands Cadastre

Inundation Category	Limits	Number of Land Parcels	Percentage of Total Cadastral Parcels	Hectares	Percentage of Total Cadastral Area
1	0 to 0.5m	405	4.6%	1,086 ha	10.2%
2	0.5 to 1m	340	3.9%	719 ha	6.8%
3	1 to 1.5m	165	1.9%	527 ha	5.0%
4	1.5 to 2m	79	0.9%	306 ha	2.9%
5	2m plus	26	0.3%	43 ha	0.4%
Total		1,015	11.5%	2,681 ha	25.3%

Flood Prone Land

Here we found that 5,972 of the 8,827 land parcels in the Redlands cadastre (approx 68%) were on or adjacent to land that is classified as Drainage Constrained, or within a Flood Regulation Line or a Flood and Tidal Surge Regulation Line. Similarly, we found that 824 of 3,931 Redlands roadways (approx 21%) were on or adjacent to land that is classified as Drainage Constrained, or within a Flood Regulation Line or an Flood and Tidal Surge Regulation Line. As expected, virtually all stormwater collection infrastructure (head walls, box culverts and open drains) are in low-lying areas, while the pipelines and manholes are more widely distributed across the City.

4.2. Issues for Planning and Development

Table 11 summarises the key issues for Planning and Development, and correlates these with key climate stressors.

The impact of drought on Tourism, and on Agriculture and Horticulture, do not have a spatial components, but are developed below as a qualitative economic and social analysis. The impact of storms and rising sea level on Redlands' marine industries is a substantial question, and was relegated to the group of more detailed follow-up analyses. The (remaining) impact of rising sea level on coastal open space is an issue that spanned several criteria for Redlands — planning and development being one, but, more obviously, environment. The inundation of coastal open space is discussed with other foreshore environmental issues in the following section of this report (page 75).

Table 11: Key Issues for Planning and Development

Key Issues	Climate Stressor			
	Storms	Droughts	Flood Waters	Coastal Inundation
Marine industries	++	-	-	+++
Tourism	-	+++	+	-
Agriculture and horticulture	+	+++	-	+++
Coastal open space	++	-	-	+++

Key: +++ (major potential impact); ++ (moderate potential impact); + (minor potential impact)

Tourism in Redlands

Redland City has a thriving tourist industry, centred on its beaches, foreshores and parks, North Stradbroke Island,(NSI) the Bay Islands (SMBIs) and cultural attraction such as the Redlands Art Gallery.

ABS Census data provides information on employment by industry at the local government level. Tourism-related industries included in the breakdown are 'accommodation and food services' and 'arts and recreation services'. These industries employed 3,264 residents and 668 residents, respectively, in Redlands in 2006 (latest Census data available). This corresponded to 5.3% and 1.1% of total employment in Redlands.

Table 12: Employment by Tourism Related Industry, Redland City, 2006 ABS Census Data

Industry	Number	Percent
Accommodation and food services	3,264	5.3%
Arts and recreation services	668	1.1%

Source: ABS 2006, Census of Population and Housing, based on OESR, Redland City Economic Snapshot, 2008.

Employment in both industry sectors has grown over the past decade – the number of jobs in each sector grew by approximately 45% for 'accommodation and food services' and 55% for 'arts and recreation services' between 1996 and 2006.

ABS Census data relates to the number of Redlands residents employed in these industries. However, to the extent that Redlands residents are employed in these industries but outside Redland City, then the ABS Census data on employment may overstate the economic significance of these industries in Redland City.[3]

Another indicator of the significance of the tourism industry is provided by the ABS's Tourism Accommodation small area data, which provides data on takings from tourist accommodation. Numbers of tourist accommodation establishments, persons employed and takings are provided below based on December 2008 data (released April 2009).

[3] In 2006, only 40% of Redland City residents worked in Redland City; the remainder work in Brisbane City and Logan City. The industries in which most residents work outside Redland City are manufacturing and construction. However, this data is not publicly available for the tourism-related industries.

Table 13: Tourism accommodation data for Redland City, 2008

Type of establishment	No. of establishments (Dec Quarter 2008)	Persons employed (Dec Qtr 2008)	Takings from accommodation (2008)[4]
Hotels, motels and serviced apartments, 5 or more rooms	9	216	$5,812,859
Holiday flats, units and houses	7	22	$4,458,202
Caravan parks	2	n/a	n/a
Visitor hostels	1	n/a	n/a

Source: ABS Tourist Accommodation Data, Queensland 2008.

Based on the limited data provided above, it is apparent that tourism is a growing industry in Redland City. Further, leisure activities associated with tourism provide a range of intangible, non-market values that are not readily measurable in monetary terms including recreation, health and wellbeing, education and cultural heritage. Previous studies indicate that these non-market values are likely to be as important to Redlands and to the local community as the market values of tourism.

It is apparent from the climate change risk assessment workshop that both the market and non-market values of tourism are at risk from climate change. The risk assessment workshops highlighted risks associated with sea level rise and increased storm activity as the most significant climate change risks for tourism in Redlands. A particular risk is the potential for 'significant degradation of beaches and foreshores through coastal inundation'. However, further research will be required to quantify this risk for tourism and for the broader economy of Redlands.

Ferry inoperability

Key risks identified by Council during the risk assessment workshops were barge and ferry inoperability owing to bad weather. The project team contacted ferry service providers (Sea Stradbroke and Stradbroke Ferries) to determine the types of weather conditions which required ferry operators to cancel or delay their services; how often in a typical year (e.g. number of days) this occurred; whether there were ever runs of days (even weeks) when the ferry could not be operated; and the impact of delays/cancellations on ferry services to the Redlands community.

Steve Eiszele of Sea Stradbroke provided information that assists in further understanding the nature of this risk.[5] He noted that Sea Stradbroke are unable to operate if there are winds from the south-south east of greater than 30 knots (i.e. 70km winds). On average, Sea Stradbroke are affected approximately six days per year (based on 2008). In other words, on average services appear to be affected on less than 2 percent of days per year. Further, services tend not to be affected for full days. This is because often winds will

[4] It is important to note that revenue data such as accommodation takings are a measure of economic activity but not necessary of the economic value of the tourism industry in Redlands.

[5] Personal communication: 15 April 2008.

moderate during the day and services can be 'sneaked in'. Moreover, the six days are not generally consecutive, but 'one-offs'.

The other ferry service provider, Stradbroke Ferries, is unable to operate if there are winds exceeding 30 knots from the south-south west. Therefore, if one ferry service cannot operate due to bad weather conditions, the other may still be able to do so.

However, this is complicated by the fact that if Sea Stradbroke cannot operate, it must tie its ferry up in the berth at Cleveland, which then means that Stradbroke Ferries cannot operate either because there is insufficient space for it to manoeuvre safely into the berth. The reverse does not apply because Stradbroke Ferries has two berths – i.e., if Stradbroke Ferries is unable to operate due to SWW winds >30 knots, it can berth its ferries at Dunwich, which means that Sea Stradbroke can still operate.

Current climate projections for South East Queensland indicate the potential for an increase in the intensity but not frequency of storms. This would suggest that ferry and barge services may not necessarily be subject to a significant increase in service disruption under a future climate regime.

Agriculture and horticulture in Redlands

The risk assessment workshops indicated that the main agricultural and horticulture industries in Redlands are poultry industries and lifestyle horticulture, especially nurseries and flower growers.

ABS Census data do not provide a breakdown at this level of detail, but an indication of the significance of the 'agriculture, forestry and fishing' industry can be obtained. In 2006, 464 in Redlands were employed in this industry, representing 0.8% of total employment in Redlands. Thus, the economic and social significance of these sectors appears to be small and, moreover, has been decreasing over the last decade. Between 1996 and 2006 (the latest Census data available), employment of Redlands residents in the industry fell by 387 persons, from 851 to 464 persons. The ABS National Regional Profile for Redland City indicates that 2,641.2 ha are devoted to production of agricultural commodities, with vegetables accounting for 99.3 ha, orchard trees 53.8 ha and fruit 88.2 ha. A breakdown of agricultural commodity values is not provided at the level of Redland City.

Based on the limited data provided above it is unlikely that the impacts of climate change on the region's agricultural sector would have significant implications for the broader economy and society of Redlands.

4.3. Issues for Environmental Management

Table 16 summarises the key issues for Environmental Management, and correlates these with key climate stressors.

The health of key Redlands ecosystems is an important issue for Council, the community and for various State and Commonwealth government agencies. We noted in the write-up of the risk assessment workshop that it would be helpful to obtain attribute data for the environmental values of key ecosystems within the City, including a list of animal and (as relevant) plant populations and a metric describing their sensitivity or intrinsic value to ecosystem health and biodiversity. Regional ecosystems should also be included. This is a substantial undertaking, and was relegated to the more detailed follow-up studies (section

5). In the discussion below we provide some simple spatial assessment of the relative exposure of key habitat classes.

The sustainability of Redlands beaches is also a complex issue, and one with additionally complex jurisdictional boundaries. As beaches are clearly impacted by rising sea level and coastal inundation, there was little to be gained from a cursory qualitative assessment, and this issue was also relegated to detailed follow-up assessment.

The more specific impact of storms and rising sea level on Redlands' foreshores is again complex issue, and will be included in the follow-up assessments. That said, some preliminary (essentially qualitative) spatial assessment has been undertaken to better understand the extent of this problem and to assist with the adaptation planning component of the project.

Similarly, the extent bushfire prone land and the correlation of this with key Redlands assets is an issue that can be clarified to some extent through simple spatial assessment, and is dealt with below. Finally, as Redlands has a landslide hazard overlay this will be presented and discussed.

Table 12: Key Issues for Environmental Management

Key Issues	Climate Stressor			
	Storms	Droughts	Flood Waters	Coastal Inundation
Health of significant ecosystems	+++	+++	+++	+++
Health of significant aquatic ecosystems	-	-	-	-
Sustainability of Redlands foreshores	-	-	-	+++
Sustainability of Redlands beaches	+++	-	-	+++
Impact of bushfires	-	+++	-	-
Escalation of landslides	+++	-	+++	-
Escalation of acid sulphate soils	-	-	+++	+++

Key: +++ (major potential impact); ++ (moderate potential impact); + (minor potential impact)

Redlands Habitat

One of the spatial datasets that we were provided with gives a breakdown of key habitat areas within the Redlands Shire. By correlating this with a 25mx25m gridded mask of the coastal inundation dataset, we were able approximate the extent of exposure of the different habitat classes.

A pictorial illustration of the approach is given Figure 6, and the outcomes of the process are summarised in Table 13. The information is likely to be useful to participants in the adaptation planning process who will be seeking to better understand the extent to which key ecosystems in Redlands are likely to be affected by climate change. The analysis shows, for example, that whilst a substantial proportion of the habitat parcels (as delimited in the spatial dataset) is likely to be affected by inundation, very little of the total or class-specific area is.

Figure 6: Gridded Area Affected by Inundation

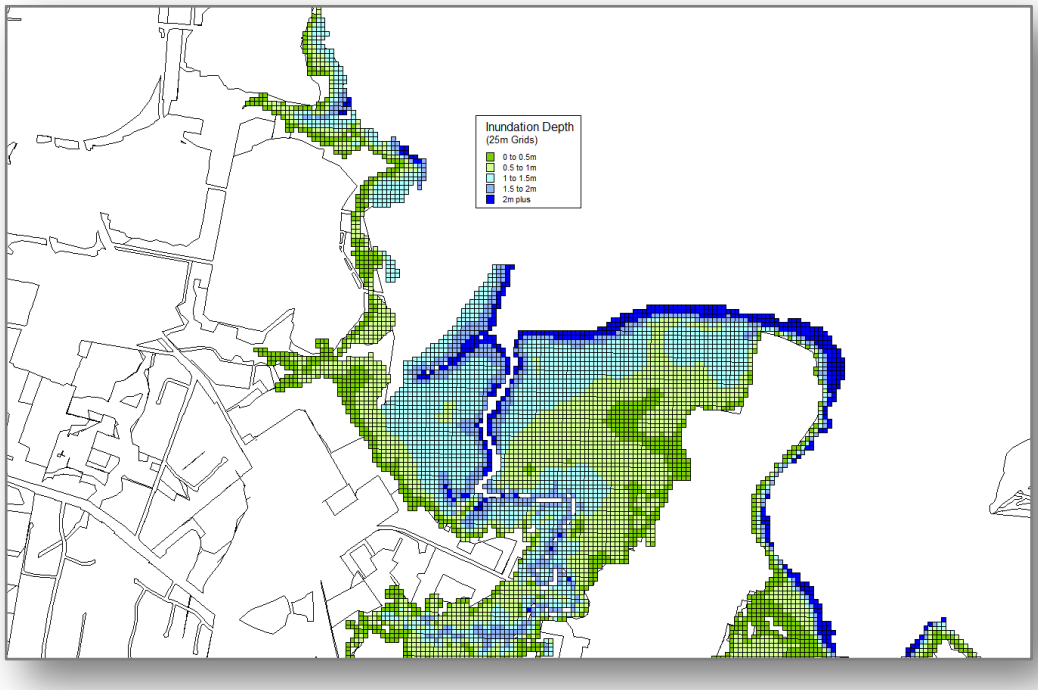


Table 13: Redlands Habitat Affected by Coastal Inundation

Class	Inundation Depth Category	Number of Parcels Affected	Percentage of Parcels Affected	Gridded Area Affected	Percentage of Total Habitat Area Affected
Bushland Habitat 644 Parcels 9,380 ha	0 to 0.5m	100	15.5%	96 ha	1.0%
	0.5 to 1m	88	13.7%	107 ha	1.1%
	1 to 1.5m	33	5.1%	24 ha	0.3%
	1.5 to 2m	4	0.6%	4 ha	0.0%
	2m plus	0	0.0%	0	0.0%
Enhancement Corridor 400 Parcels 1,051 ha	0 to 0.5m	73	11.3%	59 ha	0.6%
	0.5 to 1m	59	9.2%	32 ha	0.3%
	1 to 1.5m	21	3.3%	6	0.1%
	1.5 to 2m	2	0.3%	0	0.0%
	2m plus	0	0.0%	0	0.0%
Enhancement Habitat 411 Parcels 2,104 ha	0 to 0.5m	13	2.0%	6 ha	0.1%
	0.5 to 1m	11	1.7%	5 ha	0.1%
	1 to 1.5m	3	0.5%	0	0.0%
	1.5 to 2m	0	0.0%	0	0.0%
	2m plus	0	0.0%	0	0.0%
Enhancement	0 to 0.5m	5	0.8%	3 ha	0.0%

Class	Inundation Depth Category	Number of Parcels Affected	Percentage of Parcels Affected	Gridded Area Affected	Percentage of Total Habitat Area Affected
Linkage 205 Parcels 363 ha	0.5 to 1m	2	0.3%	0	0.0%
	1 to 1.5m	0	0.0%	0	0.0%
	1.5 to 2m	0	0.0%	0	0.0%
	2m plus	0	0.0%	0	0.0%
Koala Habitat 866 Parcels 964 ha	0 to 0.5m	19	3.0%	4 ha	0.0%
	0.5 to 1m	8	1.2%	1	0.0%
	1 to 1.5m	1	0.2%	0	0.0%
	1.5 to 2m	0	0.0%	0	0.0%
	2m plus	0	0.0%	0	0.0%
Marine Habitat 239 Parcels 976 ha	0 to 0.5m	26	4.0%	10 ha	0.1%
	0.5 to 1m	50	7.8%	74 ha	0.8%
	1 to 1.5m	41	6.4%	75 ha	0.8%
	1.5 to 2m	21	3.3%	12 ha	0.1%
	2m plus	4	0.6%	1 ha	0.0%

Redlands Heritage Sites and Trees

A spatial dataset of heritage site in the Redlands Shire was also provided. By correlating this with a 25mx25m gridded mask of the coastal inundation dataset (Figure 6), we were able approximate the extent of exposure of the different heritage assets (Table 14). The information might be helpful to participants in the adaptation planning process who will be seeking to better understand the extent to which key heritage assets in Redlands are likely to be affected by climate change. If particular instances highlighted in the table are of interest to participants, then a more detailed individual-based analysis of heritage assets would be warranted.

Table 14: Redlands Heritage Site Affected by Coastal Inundation

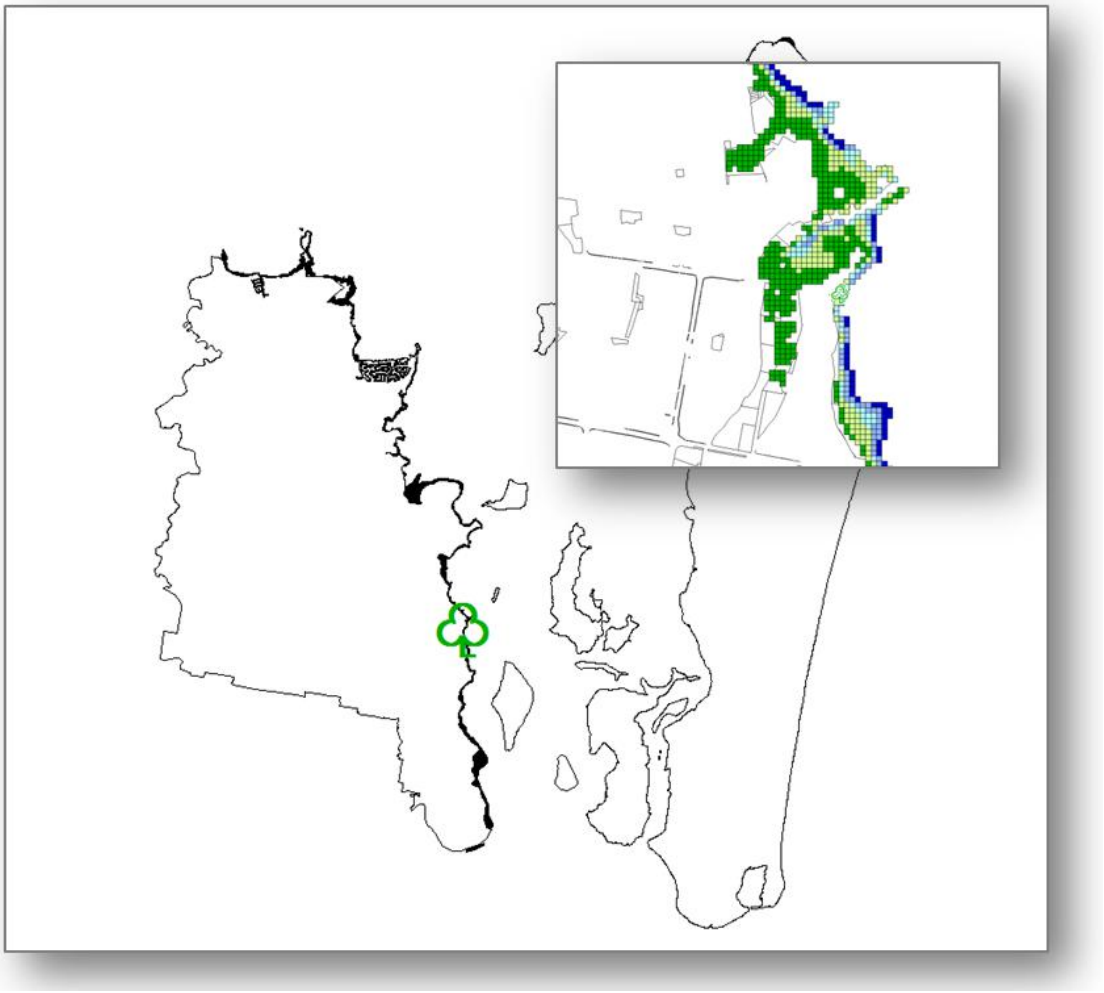
Description	Inundation Depth Category	Gridded Area Affected
Courthouse Restaurant; c. 1853 painted brick; boat-like profile to veranda balustrade	2	0.1 ha
	3	0.1 ha
Digitised Canopy	1	0.1 ha
	2	0.1 ha
	3	0.2 ha
	5	0.1 ha
Land reserve, panoramic views, mature trees	1	0.3 ha
	2	0.2 ha
	3	0.4 ha
	4	0.1 ha
Low set timber frame residence on timber stumps	1	0.4 ha
Ormiston, remnants of timber bridge	1	0.3 ha

Description	Inundation Depth Category	Gridded Area Affected
	2	0.6 ha
	3	0.1 ha
Recreation reserve; promenade of pine trees near foreshore	1	4.8 ha
	2	1.3 ha
	3	0.4 ha
	4	0.3 ha
Remnants of timber jetty; extensive trees	1	0.1 ha
	2	0.2 ha
Roll of Honour	1	1.0 ha
	2	0.6 ha
	3	0.1 ha
Single storey/ two storey masonry hotel	1	0.1 ha
Timber framed hexagonal tower, narrow walkway to upper level; moved to new site	1	0.1 ha
	2	0.1 ha
Unnamed asset	1	2.7 ha
	2	1.4 ha
	3	0.6 ha
	4	0.1 ha

Inundation depth Categories: (1) 0 to 0.5m;, (2) 0.5 to 1m; (3) 1 to 1.5m; (4) 1.5 to 2m; (5) greater than 2m

Although not included in the tabulation of heritage assets (Table 14), we also identified two heritage listed trees that stand within cells listed as inundation category 3 (1.5 to 2m). The location of the two trees is shown in Figure 7. As for other heritage assets, this issue could be investigated more closely if i was considered a priority.

Figure 7: Heritage Trees Affected by Inundation



Redlands Foreshores

One of the spatial datasets that we were provided with gives a breakdown of foreshore buffers within the Redlands Shire. By correlating this with a 25mx25m gridded mask of the coastal inundation dataset, we were able approximate the extent of exposure of the different habitat classes.

A pictorial illustration of the approach is given in Figure 8, and the outcomes of the process are summarised in Table 14. The information is likely to be useful to participants in the adaptation planning process who will be seeking to better understand the extent to which foreshore buffers in Redlands are likely to be affected by climate change. The analysis shows, for example, that a relatively small proportion of the Redlands foreshore buffer is likely to be inundated to a depth greater than category 3 (1.5 to 2m).

Figure 8: Foreshore Buffers Affected by Inundation

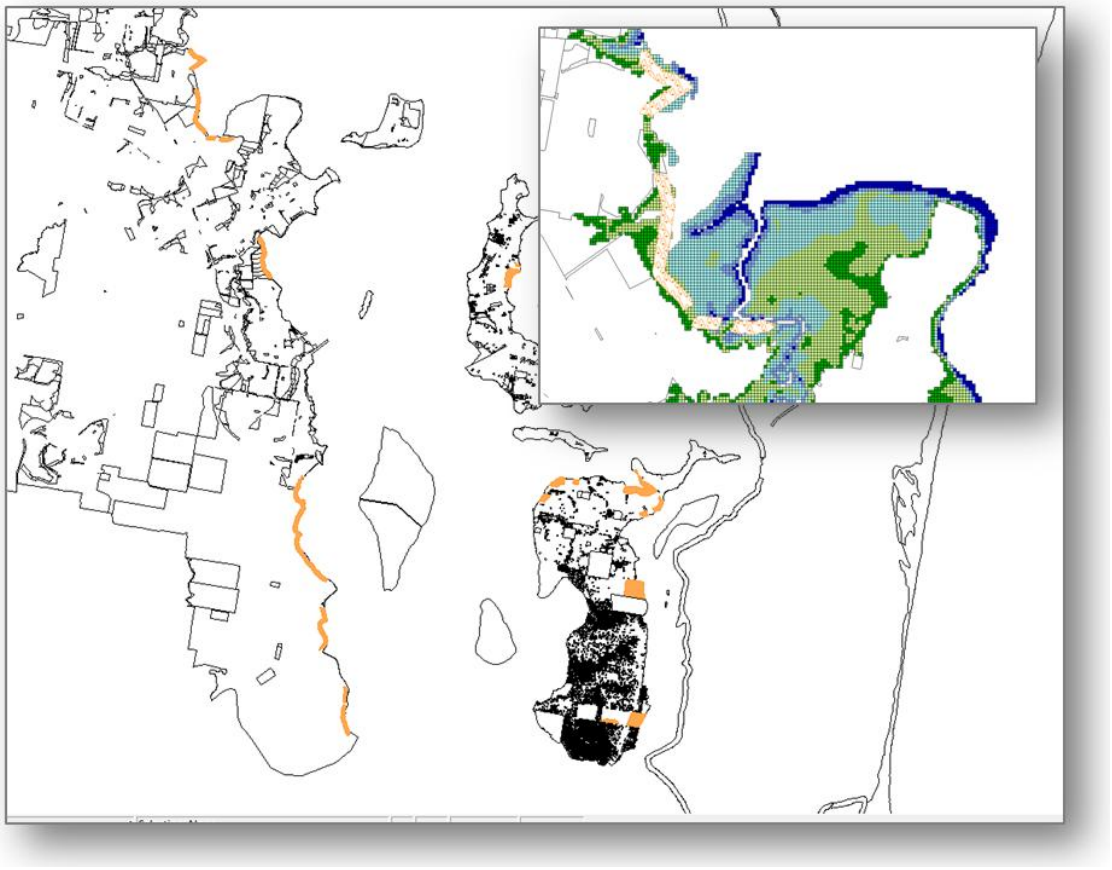


Table 15: Redlands Foreshore Buffers Affected by Coastal Inundation

Inundation Depth Category	Number of Affected Gridded Cells	Gridded Area Affected	Percentage of Buffer Area Affected
1	351	21.9	13.2%
2	445	27.8	16.8%
3	247	15.4	9.3%
4	91	5.7	3.4%
5	15	0.9	0.6%

Inundation depth Categories: (1) 0 to 0.5m;, (2) 0.5 to 1m; (3) 1 to 1.5m; (4) 1.5 to 2m; (5) greater than 2m

Bushfires in Redlands

Redlands has developed a bushfire hazard overlay for the City, as shown in Figure 9. By correlating this overlay with key natural or built assets, the extent of exposure of such assets to bushfires can loosely be approximated. By way of example, a correlation of the hazard overlay with the Redlands cadastre shows that a total of 604 Redlands land parcels are within or adjacent to a zone classified as Medium bushfire risk.

It is difficult to extrapolate from the hazard overlay to obtain an estimate for the (spatial and non-spatial) extent to which bushfire hazard is likely to change for Redlands, under the

2030 and 2070 climate change scenarios. The most robust approach is perhaps to allow the spatial extent of exposure to remain as it is (Figure 9) but to consider that the number of high or extreme fire danger days experienced each year is likely to increase.

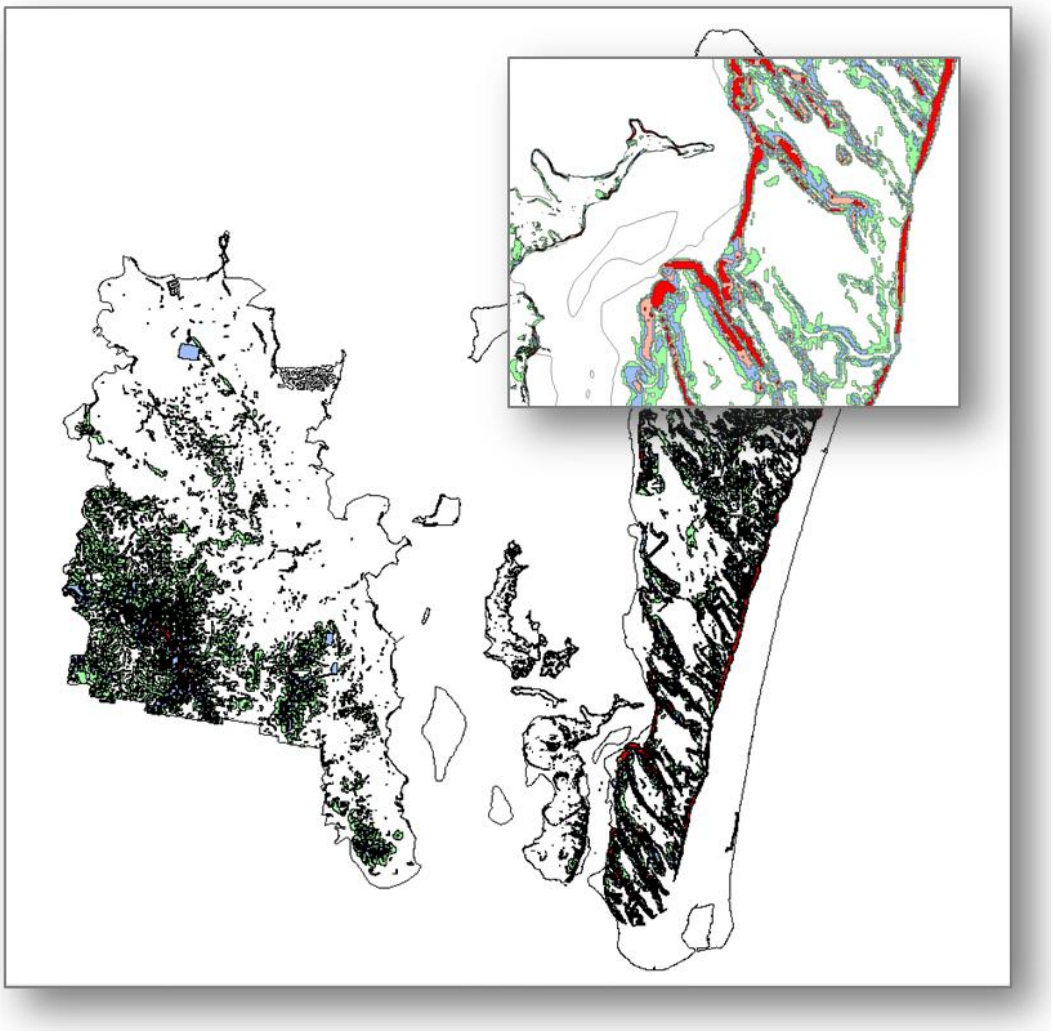
Figure 9: Redlands Bushfire Hazard Overlay

Landslides in Redlands

Redlands has also developed a landslide hazard overlay for the City, as shown in Figure 10. By correlating this overlay with key natural or built assets, the extent of exposure of such assets to landslides can loosely be approximated. By way of example, a correlation of the hazard overlay with the Redlands cadastre shows that a total of 768 Redlands land parcels are within or adjacent to a zone classified as High or Very High landslide risk.

It is difficult to extrapolate from the hazard overlay to obtain an estimate for the (spatial and non-spatial) extent that landslide hazard is likely to change for Redlands, under the 2030 and 2070 climate change scenarios. The most robust approach is perhaps to allow the spatial extent of exposure to remain as it is (Figure 10) but to consider that the number of occasions on which landslides occur in the City is likely to increase for the 2030 and 2070 rating periods.

Figure 10: Redlands Landslide Hazard Overlay



4.4. Issues for Community and Social Planning

Table 16 summarises the key issues for Community and Social Planning, and correlates these with key climate stressors.

Table 16: Key Issues for Community and Social Planning

Key Issues	Climate Stressor			
	Storms	Droughts	Flood Waters	Rising Sea Level
Home-assisted and respite care	+++	-	+++	-
Emergency recovery services	+++	-	+++	-
Arbovirus disease	-	-	-	+++
Public safety in extreme weather events	+++	-	+++	-

Key Issues	Climate Stressor			
Sustainability of sportsgrounds	+	+++	+	-
Council liability for developments	-	-	+	+++
Inundation of coastal recreation areas	-	-	-	+++

Key: +++ (major potential impact); ++ (moderate potential impact); + (minor potential impact)

Home-Assisted Respite Care

We identified during the risk assessment workshop a need for a more detailed and systematic examination of the possible impact of climate change on home respite care in Redlands, and on the adequacy of Council's disaster recovery services. These issues are discussed in section 5.

Arbovirus Diseases

The impact of coastal inundation and increased frequency of flooding on mosquito populations in Redlands, and the combined impact of this and more general trends in Australia on the southern migration of arbovirus diseases, are complex issues. The availability of good spatial data about mosquito populations and suitable breeding or expansion sites is not certain. The southern migration of important arbovirus diseases is also fraught with some uncertainty, and some disagreement within the scientific and public health communities. In view of these difficulties, there was little that could be achieve d through superficial qualitative assessment — both issues are discussed further in section 5.

Public Safety

The impact of climate change on the extent to which public safety is likely to be threatened by extreme weather events is a largely non-spatial question. It hinges on issues such as the nature of such events (e.g. extremely violent storms versus flash flooding); the rapidity with which they occur and the extent to which the public can be warned; and the extent to which Council, other government agencies and the community can take action to improve the ability of homes and infrastructure to withstand such events. These are again complex and multifaceted issues, and relegated to detailed follow-up assessment (section 5).

Sustainability of Sportsgrounds

The sustainability of sportsgrounds through more frequent droughts and hotter weather will hinge largely on the sustainability of existing watering arrangements or the ability of Council to develop alternatives. Some modifications to the intensity of grounds use and grounds management practices may also assist. A detailed analysis of the Redlands' sporting facilities, their inherent value to the community and the extent to which they are likely to be threatened by climate change would be valuable. This is discussed in section 5.

Council Liability for Developments

Council liability for developments on land that is subsequently inundated is a matter for Council's legal advisors, who might support the commissioning of a review of current case law and other relevant issues. One of the more obviously pressing aspects of this question is the selection of a spatial dataset that Council believes best represents the impact of climate change on sea level. Cardno have provided a range of datasets, and one of these

could be selected by Council for use in its Planning Scheme. That said, we have reviewed the Cardno modelling and have suggested that a more conservative dataset would be appropriate — i.e. a dataset that showed a great depth and extent of inundation, and more explicitly accounted for sea level rise through 2030, 2070 and 2100.

Inundation of Recreation Areas

The remaining issue for Community and Social Planning was the extent to which recreation areas might be threatened by coastal inundation. We discuss this in the recommendations and detailed follow-up assessment (section 5). We also provide some superficial spatial analysis of the extent to which Redlands foreshores are likely to be threatened by inundation in the discussion of Environmental Management (above). Participants in the adaptation planning stage of the project are referred to that discussion as preparation for the workshop.

5. Follow-Up Assessments

In this section of the report we describe recommendations for more detailed follow-up spatial and other assessments.

A brief summary of the recommendations about the follow-up assessments is given in Table 17 overleaf. We don't maintain that all of this work need be done immediately, and suggest only that RCC review the summary — and, as relevant, the more detailed discussions of each risk — and draw their own conclusions about the assessments that they consider most critical to the integrity of the exercise.

This work is distinct from the detailed spatial modelling of sea level, storm surges, severe storms and flooding that is being carried out by GEMS (Dr Graeme Hubbert).

Table 17: Recommendations for Follow-Up Assessment

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Infrastructure	Buildings	Council buildings damaged through subsidence and shifting foundations with increased intense rainfall	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC buildings. Include attributes for the significance or the cost of each structure, its age and its stage in the cycle in building life and replacement. - Obtain spatial data for soil types in the City of Redland. - Correlate the location and attributes of RCC buildings with soil types to determine the assets most exposed to subsidence and the consequences of increased risk of subsidence as a result of climate change.
Infrastructure	Coastal Infrastructure	Increased damage to caravan parks through storm activity	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC caravan parks. Include attributes for the size of each park, its importance to Redlands tourism, the extent an value of its amenities, etc. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of RCC caravan parks with storm tides and flooding to determine the parks most exposed and the consequences of increased risk of damage as a result of climate change.
Infrastructure	Coastal Infrastructure	Increased damage to pontoons, marina, jetties, piles through storm tide	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC marine infrastructure — pontoons, marina, jetties, piles, etc. Include attributes for the significance or the cost of each item, and its age or stage in the replacement cycle. Also include attributes for the sensitivity of each structure to storm tides and storm surges — for example, the height and tolerance of individual jetties. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of RCC infrastructure with storm tides and flooding to

Key Element	Risk Category	Risk Name	Follow-Up Assessment
			determine the assets most exposed and the consequences of increased risk of damage as a result of climate change.
Infrastructure	Coastal Infrastructure	Increased damage to sea walls (armouring) through storm tide	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC sea walls. Include attributes for the significance or the cost of each wall, and its age or stage in the replacement cycle. Also include attributes for the sensitivity of each structure to storm tides and storm surges — for example, the height and tolerance of individual walls. - Obtain spatial data for the infrastructure and communities exposed to damage when individual sea walls are overwhelmed or damaged. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the attributes of individual sea walls with storm tides and flooding to determine those most exposed and the consequences of increased risk of damage as a result of climate change.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Infrastructure	Coastal Infrastructure	Low-lying public infrastructure damaged by flooding	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of RCC infrastructure. Include attributes for the significance or the cost of each item. Exclude RCC buildings (above), and focus instead on RCC roads, bridges, footpaths, boardwalks, etc. - Obtain spatial data (hazard overlay) for storm tides and flooding. This will be embellished through GEMS modelling. - Correlate the location and attributes of RCC infrastructure with storm tides and flooding to determine the assets most exposed; and the consequences of increased risk of damage as a result of climate change.
Infrastructure	Other	Closed landfills inundated through storm surge	Spatial assessment would help to clarify this risk – in brief: - Obtain spatial data for closed landfills. - Obtain spatial data for Shire zones and key RCC, community, commercial and environmental assets. - Obtain spatial data (hazard overlay) for storm tide heights and flooding. This will be embellished through GEMS modelling. - Correlate the exposed landfills of with storm tides and flooding to determine those most exposed to inundation. - Correlate exposed landfills with Shire zones and assets to determine the extent to which such exposure might impact on RCC.
Infrastructure	Power	Loss of power as a result of overload	Spatial analysis is not required, although some identification of the buildings without in-house generators (or access points for the attachment of mobile generators) might help to quantify the extent to which RCC is exposed through power failure. Some additional assessment of the robustness of regional and local power infrastructure to increased demand (as might occur in a heatwave) would also be helpful.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Infrastructure	Power	Loss of power as a result of storms	Spatial analysis is not required, although some identification of the buildings without in-house generators (or access points for the attachment of mobile generators) might help to quantify the extent to which RCC is exposed through power failure.
Infrastructure	Stormwater	Stormwater drains blocked through reduced average rainfall or drought	Spatial assessment would help to clarify this risk – in brief: - A spatial overlay of RCC stormwater reticulation system has been provided. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have also been provided. - Prepare an assessment methodology that correlates spatial predictors for exposure to flooding as a result of stormwater with assets at risk – RCC assets, as well as community and commercial assets. Ground truth the assessment methodology with observed impacts of stormwater backwash. - Use the assessment methodology to better estimate the extent of likely harm to RCC as a result of stormwater backwash and flooding.
Infrastructure	Stormwater	Stormwater drains overwhelmed by intense rainfall	Spatial assessment would help to clarify this risk – in brief: - A spatial overlay of RCC stormwater reticulation system has been provided. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have also been provided. - Prepare an assessment methodology that correlates spatial predictors for exposure to flooding as a result of stormwater with assets at risk – RCC assets, as well as community and commercial assets. Ground truth the assessment methodology with observed impacts of stormwater backwash. - Use the assessment methodology to better estimate the extent of likely harm to RCC as a result of stormwater backwash and flooding.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Infrastructure	Stormwater	Stormwater treatment systems overwhelmed	Spatial assessment is not required. It might, however, be helpful to document and describe the range of stormwater treatment systems and to systematically assess the sensitivity of each to stormwater overload. From this, a more searching assessment of the direct and indirect impacts of treatment overload on RCC could be made.
Infrastructure	Transport	Barge inoperable in rough weather	Although spatial analysis is not required, an assessment of the number of days that the NSI barge is inoperable — and the extent to which the ferry can be substituted — would be helpful. This assessment could be extended (as relevant) to any other barged services that might operate on other islands or inaccessible coastal communities in the City.
Infrastructure	Transport	Ferry inoperable in rough weather	Although spatial analysis is not required, an assessment of the number of days that the NSI ferry is inoperable would be helpful. This assessment could be extended (as relevant) to any other ferry services that might operate on other islands or inaccessible coastal communities in the City.
Planning and Development	Strategic Planning	Inadequate planning for the impact of rising sea level on marine industries	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of marine industry infrastructure in the City. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of marine industry infrastructure with storm tides and flooding to determine the infrastructure most exposed to rising sea levels and the consequences to RCC of failing to consider the impacts rising sea level on such infrastructure as a part of its strategic planning for the City.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Planning and Development	Strategic Planning	Inadequate planning for the impact of water restrictions, transport difficulties, rising temperatures and increased storm activity on tourism	Spatial analysis is not required. Some more detailed analysis of the sensitivity of the key Redlands tourism industries to the impacts of climate change might, however, be helpful. This would include (inter alia) an assessment of the impact of the recent drought, storm cycles and other extreme weather events on visitor numbers and tourism revenue.
Planning and Development	Strategic Planning	Inadequate planning for the impact of water stress, drought, storms and temperature on agricultural (poultry) and horticultural (flower farming and others) industries	Spatial analysis is not required. Further analysis is required to determine the sensitivity of the Redlands poultry industry to likely changes in climate key parameters. The robustness of the regional grains industry should also be examined, as should opportunities for alternative sources of poultry feed. The exposure of the horticulture industry to water shortages in the past and future (with new water arrangements) is a separate issue, and should be examined. With these issues clarified, the ratings for this risk might be altered substantially.
Planning and Development	Strategic Planning	Insufficient coastal open space as a result of rising sea level and coastal inundation	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Environmental Management	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through coastal inundation	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. - Obtain attribute data for the environmental values of coastal open space buffers throughout the City. This should include a list of animal and (as relevant) plant populations, and a metric describing their sensitivity or intrinsic value to ecosystem health and biodiversity. Regional ecosystems should also be included. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.
Environmental Management	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through persistent water stress	Spatial analysis may not be needed here as the regional ecosystems have been mapped and are well documented understood by RCC. It might, however, be helpful to assess the drought-sensitivity of each regional ecosystem against its inherent value to the City. It might also be helpful to further enunciate the RCC response to water stress (if any) and to further explore other issues associated with the impact of water stressed ecosystems on RCC — specifically.
Environmental Management	Biodiversity and Catchments	Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	Spatial analysis may not be needed here as the regional ecosystems have been mapped and are well documented understood by RCC. It might, however, be helpful to assess the storm-sensitivity of each regional ecosystem against its inherent value to the City. It might also be helpful to further enunciate the RCC response to storms (if any) and to further explore other issues associated with the impact of storm-damaged ecosystems on

Key Element	Risk Category	Risk Name	Follow-Up Assessment
			RCC — specifically.
Environmental Management	Biodiversity and Catchments	Significant harm to aquatic animal or plant populations or ecosystem health through ocean acidification	Spatial analysis is not required. It would , however, be valuable to carry out some desktop research into the likely impacts of climate change on key aquatic ecosystems. This might take the form of a minor desktop review, as much of this work will have been summarised in Australian and overseas literature. A correlation of key findings with the more significant aquatic communities in Redlands waters could then be undertaken and this reviewed.
Environmental Management	Bushfire Management	Significant harm to animal or plant species and ecosystem health through bushfires	Spatial assessment would help to clarify this risk – in brief: - Obtain the bushfire hazard overlay. - Obtain an overlay of regional ecosystems within the City. This should include a list of animal and (as relevant) plant populations, and a metric describing their sensitivity or intrinsic value to ecosystem health and biodiversity. - Correlate the location of regional ecosystems and their inherent value with bushfire hazard to determine the parts of the City where bushfire risk is most likely to be substantial and the consequences to RCC of increased bushfire risk.
Environmental Management	Coastal Management	Significant degradation of beaches and foreshores through coastal inundation	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City, with attribute data that differentiates between beaches and other forms of coastal habitat. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space data with storm tides and flooding to determine the parts of the City where encroachment on beaches is most likely to be substantial, and the consequences to RCC of failing to consider maintaining this buffer as the coastal inundation progresses.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Environmental Management	Coastal Management	Significantly increased algal blooms (Lyngbya majuscula)	No spatial analysis is required. It might, however, be valuable to assess more systematically and quantitatively the extent of the threat to RCC, should algal blooms become more common or spread to involve mangrove areas.
Environmental Management	Other	Increased incidence and severity of landslide through intense rainfall	The landslide hazard overlay provides a spatial rating of this hazard across the City.
Environmental Management	Other	Significant escalation of the distribution of acid sulphate soils	The acid sulphate soils overlay provides a spatial rating for this hazard across the City. Further analysis of the extent to which the acid sulphate soils issue confronting RCC might be affected by climate change (principally, sea level rise and coastal inundation), would enable this risk to be re-assessed and rated.
Community and Social Planning	Aged Care and Health	Increased need for home-assisted and respite care and associated funding, as a result of temperature changes and storms	Spatial analysis is not required. Some further analysis of this issue would however, enable the risk to be assessed more rigorously (probably quantitatively) and re-rated as required. In particular, it would be useful to assess the threshold at which demand for: (a) Home Assist; and (b) respite care would exceed fixed resources (e.g. carers or available beds) or funding. This could be correlated with historical data, to determine whether any previous periods of sustained high temperatures or violent weather have measurably altered the requirement for such services. Once obtained, this estimate could be correlated with the increase temperatures and frequency of severe storms that is likely to accompany climate change in the short, medium and longer term.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Community and Social Planning	Emergency Services	Demand for recovery services increased through increased storms and flooding	Further review of the RCC disaster recovery plans — and the status of preparation and planning — would enable this risk to be re-assessed and re-rated.
Community and Social Planning	Public Health and Safety	Harm to lifestyle and general wellbeing as a result of increased midge or mosquito density	Further spatial and other desktop analysis of this issue would be helpful. In particular, spatial data for mosquito populations could be correlated with waterways, regional ecosystems and storm tide and flooding overlays to determine the extent to which mosquito habitat is likely to alter under each of the three temporal scenarios. These desktop assessments would help to better understand the collective consequences to RCC associated with altered mosquito distribution and density. At this more detailed level, however, the issues would be better separated with individual assessments for each of the major species of mosquito or midge. These assessments would include spatial correlations (as above) but would also include consideration of the relative impact of each species on lifestyle, and the costs and logistics of control.
Community and Social Planning	Public Health and Safety	Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	Further spatial and other desktop analysis of this issue would be helpful. In particular, spatial data for mosquito populations could be correlated with waterways, regional ecosystems and storm tide and flooding overlays to determine the extent to which mosquito habitat is likely to alter under each of the three temporal scenarios. It would also be helpful to obtain the costs to council and state associated with dengue fever control in affected parts of northern Australia. These desktop assessments would help to better understand the collective consequences to RCC for altered disease and mosquito distribution and density. At this more detailed level, however, the issues would be better separated with individual assessments for expanding mosquito distributions (further divided by species, as relevant), and for each of the three arbovirus diseases.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Community and Social Planning	Public Health and Safety	Public safety threatened through increased storms or flooding	No further analysis is necessarily needed, although some elaboration of the characteristics of extreme weather events that typical threaten lives might help to support this assessment. It would also be helpful to examine historical records, and determine whether lives have been lost in the City as a result of storms or flooding, and under what conditions. Esoteric deaths — such as drowning whilst playing in a stormwater drain — should not be included unless there is a clear link to future risk associated with the weather event concerned.
Community and Social Planning	Recreation Services	Recreation areas threatened by coastal inundation	Spatial assessment would help to clarify this risk – in brief: - Obtain a spatial overlay of coastal open space in the City. The Redlands Cadastre and zoning, as well as an elevation surface for the Redlands Shire, have been provided. Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal open space with storm tides and flooding to determine the parts of the City where encroachment is most likely to be substantial, and the consequences to RCC of failing to consider maintaining this open space as viable recreation asset as the coastal inundation progresses.
Community and Social Planning	Recreation Services	Sporting or recreational areas threatened through lack of water	No spatial analysis is required. Some further communication with RCC and minor desktop assessment would however be helpful in clarifying whether the exposure of RCC sporting facilities is likely to increase as a result of new water policies, and what this might mean to RCC in the light of more frequent droughts and dry periods and increased evapo-transpiration.

Key Element	Risk Category	Risk Name	Follow-Up Assessment
Corporate Services	Legal and Financial Services	Council liability for developments threatened by flooding or sea level	Two forms of follow-up assessment would be worthwhile to better understand (and more definitively rate) this risk. - Review of the existing case law and legal instruments; and - Spatial assessment of the extent of possible exposure of coastal developments at each of the three time periods. The review of case law and legal instruments is beyond or expertise, and might well be an activity that RCC could carry out in-house. The spatial assessment is discussed further – in brief: - Obtain a spatial overlay of coastal developments within the City, with attribute data that differentiates between residential and commercial developments and notes the date of approval. - Obtain spatial data (hazard overlay) for storm tides, flooding and coastal inundation. This will be embellished through GEMS modelling. - Correlate the location of coastal developments with storm tides and flooding to determine the developments where (at each time horizon) inundation is most likely to be a concern, and the date of approval and extent of exposure to litigation.

6. Appendix 1: Risk Register

Risk Name	Consequences	Likelihood (Current)	Priority (Current)	Likelihood (2030)	Priority (2030)	Likelihood (2070)	Priority (2070)
Infrastructure							
Council buildings damaged through subsidence and shifting foundations with increased intense rainfall	Insignificant	Rare	4	Rare	4	Rare	4
Council buildings (inland) damaged through wind, hail or flooding	Low	Unlikely	20	Unlikely	20	Unlikely	20
Council buildings (coastal) damaged through wind, hail or flooding	Low	Possible	28	Possible	28	Likely	44
Building fittings and retrofits required to accommodate temperature increases and storms	Insignificant	Likely	24	Rare	4		
Low-lying public infrastructure damaged by flooding	Low	Likely	44	Likely	44	Almost certain	48
Increased damage to pontoons, marina, jetties, piles through storm tide	Major	Unlikely	64	Unlikely	64	Rare	60
Increased damage to sea walls (armouring) through storm tide	Low	Possible	28	Possible	28	Likely	44
Increased damage to caravan parks through storm activity	Low	Unlikely	20	Unlikely	20	Rare	16
Damage to footings or timber structures through ocean acidity	Insignificant	Rare	4	Rare	4	Rare	4
Closed landfills inundated through storm surge	Low	Possible	28	Unlikely	20	Unlikely	20
Damage to microwave linkage to isolated and island communities	Insignificant	Rare	4	Unlikely	8	Possible	12
Loss of power as a result of overload	Low	Unlikely	20	Unlikely	20	Unlikely	20

Risk Name	Consequences	Likelihood (Current)	Priority (Current)	Likelihood (2030)	Priority (2030)	Likelihood (2070)	Priority (2070)
Loss of power as a result of storms	Low	Unlikely	20	Unlikely	20	Unlikely	20
Stormwater drains overwhelmed by intense rainfall	Insignificant	Possible	12	Possible	12	Likely	24
Stormwater drains blocked through reduced average rainfall or drought	Insignificant	Possible	12	Possible	12	Likely	24
Stormwater treatment systems overwhelmed	Low	Possible	28	Likely	44	Almost certain	48
Infiltration of sewerage through illegal connections to stormwater	Low	Likely	44				
Road damage through drought	Insignificant	Rare	4	Rare	4	Rare	4
Barge inoperable in rough weather	Medium	Likely	56	Likely	56	Likely	56
Ferry inoperable in rough weather	Low	Likely	44	Likely	44	Almost certain	48
Planning and Development							
Increased need for shaded/cool facilities	Low	Possible	28				
Insufficient coastal open space as a result of rising sea level and coastal inundation	Low	Rare	16	Unlikely	20	Possible	28
Inadequate planning for the impact of rising sea level on marine industries	Insignificant	Rare	4	Rare	4	Unlikely	8
Inadequate planning for the impact of water restrictions, transport difficulties, rising temperatures and increased storm activity on tourism	Low	Rare	16	Unlikely	20	Possible	28
Inadequate planning for the impact of water stress, drought, storms and temperature on agricultural (poultry) and horticultural (flower farming and others) industries	Low	Unlikely	20	Possible	28	Rare	16

Risk Name	Consequences	Likelihood (Current)	Priority (Current)	Likelihood (2030)	Priority (2030)	Likelihood (2070)	Priority (2070)
Environmental Management							
Significant harm to animal or plant populations, habitat or ecosystem health through storms and flooding	Medium	Unlikely	36	Possible	52	Likely	56
Significant harm to aquatic animal or plant populations or ecosystem health through ocean acidification	Insignificant	Rare	4	Unlikely	8	Possible	12
Significant harm to animal or plant populations, habitat or ecosystem health through coastal inundation	Low	Rare	16	Unlikely	20	Possible	28
Significant harm to animal or plant populations, habitat or ecosystem health through persistent water stress	Low	Rare	16	Unlikely	20	Possible	28
Significant harm to animal or plant species and ecosystem health through bushfires	Low	Rare	16	Unlikely	20	Possible	28
Significantly increased algal blooms (Lyngbya majuscula)	Low	Unlikely	20	Possible	28	Likely	44
Significant degradation of beaches and foreshores through coastal inundation	Low	Rare	16	Unlikely	20	Unlikely	20
Increased incidence and severity of landslide through intense rainfall	Insignificant	Rare	4	Rare	4	Unlikely	8
Significant escalation of the distribution of acid sulphate soils	Not rated	Not rated		Not rated		Not rated	
Increased pests and weeds through altered temperature and rainfall parameters	Insignificant	Rare	4	Unlikely	8	Unlikely	8
Degradation of creek ecosystems through reduced stream flow	Insignificant	Rare	4	Rare	4	Unlikely	8
Significantly increased pollution of waterways through storms and flooding	Insignificant	Rare	4	Rare	4	Unlikely	8
Community and Social Planning							
Anxiety (mental health and general wellbeing) about climate	Low	Rare	16	Unlikely	20	Possible	28

Risk Name	Consequences	Likelihood (Current)	Priority (Current)	Likelihood (2030)	Priority (2030)	Likelihood (2070)	Priority (2070)
change - particularly elderly							
Increased incidence of heat stress through increased peak temperatures and heat waves	Insignificant	Rare	4	Rare	4	Unlikely	8
Increased need for home-assisted and respite care and associated funding, as a result of temperature changes and storms	Low	Rare	16	Unlikely	20	Possible	28
Demand for emergency services increased through increased storms and flooding	Low	Rare	16	Unlikely	20	Possible	28
Demand for recovery services increased through increased storms and flooding	Insignificant	Rare	4	Unlikely	8	Possible	12
Public safety threatened through increased storms or flooding	Low	Rare	16	Unlikely	20	Possible	28
Public safety threatened through altered incidence of mosquito-borne infectious diseases (e.g. dengue fever, Ross River virus disease)	Medium	Rare	32	Rare	32	Possible	52
Harm to lifestyle and general wellbeing as a result of increased midge or mosquito density	Low	Rare	16	Unlikely	20	Possible	28
Sporting or recreational areas threatened through lack of water	Low	Possible	28	Possible	28	Possible	28
Recreation areas threatened by coastal inundation	Low	Rare	16	Unlikely	20	Possible	28
Corporate Services							
Council liability for property damage through bushfires	Insignificant	Rare	4	Rare	4	Rare	4
Council liability for developments threatened by flooding or sea level	Major	Rare	60	Rare	60	Rare	60

7. Appendix 2: Climate Change and Policy Scenarios

7.1. Climate Change Scenarios

The climate change scenarios presented in Table 18 are based principally on CSIRO projections for coastal regions of southeast Queensland. These, in turn, are based on Australian and international modelling.

The scenarios are consistent with midrange projections for 2030, and with high emission scenario, mid range projections for 2070. As such, they represent the 'best estimate' climate changes (direction and magnitude) assuming substantial reductions in global greenhouse gas emissions below 'business-as-usual' are *not* achieved in the coming decades.

For most of the climate variables presented here, the greatest uncertainty lies in the magnitude rather than direction of change. Thus the trend is clear, but the rate of change is less certain. The Intergovernmental Panel on Climate Change (IPCC) for example, has stated that it is virtually certain (>99% probability) that that there will be global warming over the coming century, and that this warming will be accompanied by an increase in frequency of hot days and decrease in frequency of cold days and nights in most areas. Similarly, it is very likely (90-99% probability) that the frequency of heavy rainfall events will increase.

The key exceptions to this rule of thumb are mean rainfall, solar radiation and humidity; with the direction as well as magnitude of change to these variables being quite uncertain.

Table 18: Climate change scenarios for the City of Redland (2030 and 2070)

Climate Variable	Current	Indicative Change (relative to 1990)		Notes
Temperature		**2030**	**2070**	Average annual temperature could increase by up to 4.5°C by 2070 and the number of days over 35°C could increase up to 14 by 2070. The average annual temperature has warmed by about 0.2°C since 1990, reflecting increases in both maximum and minimum temperatures.
Average annual temperature	19	↑ 1.0°C	↑ 3.0°C	
Days per year > 35°C	1	↑ to 2	↑ to 6	
Annual potential evapo-transpiration		↑ 3%	↑ 8%	
Average rainfall		**2030**	**2070**	Average rainfall projections for the region are quite uncertain. It is possible that average rainfall will increase. On the other hand, average
Annual	1276mm	↓ 2%	↓ 5%	
Spring	223mm	↓ 3%	↓ 8%	
Summer	459mm	no change	no change	

Climate Variable	Current	Indicative Change (relative to 1990)		Notes
Autumn	381mm	↓ 2%	↓ 5%	annual rainfall could decrease by 15% or greater by 2070. Relatively high projected stream-flow reductions are linked to a number of variables including reduced rainfall and higher evapo-transpiration. In the decade to 2007, the region's average rainfall was 10% below the long term average.
Winter	213mm	↓ 3%	↓ 8%	
Annual stream flows		↓ 5-10%	↓ 10-30%	
Droughts		↑ frequency and severity		
Rainfall other		**2030**	**2070**	Rainfall in the region is likely to become more variable, with fewer rainy days but rain falling in more intense bursts. The wettest day on record in Redland occurred on 30 June 2005.
24 hr rainfall intensity (max)	266mm	↑ 10%	↑ 30%	
Flood return intervals (ARI)		↓ flash ↓ riverine	↓ flash ↓ riverine	
Number of rainy days	116	↓	↓	
Sea level rise / storm surge		**2030**	**2070**	Sea level rise projections are based on IPCC projections. They do not take into account some recent data on possible increased melt rate of the Greenland Ice Sheet.
Sea level rise	(max)	0.17m	0.49m	
Storm tide – max. height, 1:100 year ARI (Wellington Point)	1.47m	~1.67m	~2.09m	
Storm tide – change to 1:100 year ARI (worst case)	1:100	↓ to <1:20	↓ to <1:10	
Windiness and storms		**2030**	**2070**	Wind projections for the region are uncertain. However, both average wind speeds and extreme winds are more likely than not projected to increase in coastal areas, especially in winter.
Average wind speeds		↑	↑	
Extreme wind speeds		↑	↑	
Other		**2030**	**2070**	Changes to solar radiation and humidity are both unclear, both depending to a significant extent on
Solar radiation		unclear	unclear	
Humidity		unclear	unclear	

Climate Variable	Current	Indicative Change (relative to 1990)		Notes
				future cloud cover. Changes are likely to be relatively small, with the most significant increases likely to occur in Autumn.
Number of high and extreme forest fire danger days	4	↑ to 5	↑ to 8	Modelling of fire danger has not been undertaken for the region. Data presented is from the north central coast of NSW for 2020 and 2050. The length of the fire season is projected to increase also.

7.2. Policy Scenarios

The policy scenarios presented in Table 19 are for Australia and Queensland.

The scenarios reflect judgements as to the most likely direction and (where feasible) magnitude of changes in policies relevant to RCC's operations; drawing on currently available information about federal and state government policies.

The scenarios are presented for two time periods:

1. Short term (i.e. within the next 5 years); and
2. Medium term (to 2030).

It is not feasible to consider additional policy directions beyond 2030.

As with the climate change scenarios, the level of certainty about the direction of policy changes is significantly greater than the magnitude of changes, which in most cases are highly uncertain — even in the short term.

Uncertainty about the magnitude of changes reflects the large number of political, economic and social factors that influence decision-making on issues such as climate change, energy, water and waste management.

Table 19: Policy scenarios for the City of Redland (2030 and 2070)

Policy Issue	Indicative Change		Discussion and Comments
	Short term	Medium term	
Carbon prices	↑ $15-20 / t CO_{2-e}	↑ $30-80 / t CO_{2-e}	Costs associated with CO_{2-e} emissions will, for the foreseeable future, be largely driven by the 'Carbon Pollution Reduction Scheme' (CPRS). Carbon prices will **not** be set directly through the CPRS. Rather, an annual allowable emissions 'cap' will determine the number of permit allocations, which will determine the marginal cost of emissions abatement and, in turn, the market price of permits. The level at which the emissions cap is set is essentially a political decision. The annual caps for the first 10 years of the scheme are not being announced until later this year, thus there is considerable uncertainty as to the cap levels and therefore, the marginal cost of abatement in the short term. The Government's commitment to reduce national emissions by 60% below 1990 levels by 2050 helps to define the longer term carbon price. Recent modelling suggests that a cap aimed at achieving a 'politically acceptable' short term target would result in an initial carbon price of about $15-20 /t CO_{2-e}. Longer term prices will be determined by the stringency of future caps and future costs of emission reduction technologies.
Average electricity prices	↑	↑	The protracted and intense drought in southern and eastern Australia in recent years (possibly linked to climate change) has resulted in a substantial reduction in hydro-electricity output in Victoria, NSW and Queensland in 2007and increased the need to rely on more expensive gas-fired generation. This contributed to a 30% increase in the wholesale price of electricity in Queensland between 2006 and 2007, some of which has since been passed on to retail customers in 2007/2008 (11.4%) through a Queensland Competition Authority pricing decision. Projections of reduced average rainfall, runoff and increased frequency and intensity of droughts could result in further pressure on electricity prices in the short, medium and longer terms. Proposed energy policy measures such as the renewable energy target (RET) will also reinforce this trend.
Peak electricity	↔	↑ up to 400% air-	Growth in peak summer load sensitive temperature is dominated by increased sales and use of residential (and to some extent commercial) refrigerative air-conditioning. In response, there is a strong push at the

Policy Issue	Indicative Change		Discussion and Comments
	Short term	Medium term	
prices		conditioning costs	state and national levels (through the Ministerial Council on Energy) to introduce time-of-use metering for all retail customers. Some state governments have already announced a roll-out of smart metres. This response has been driven by a concern to improve price signals and economic efficiency but is also seen as a positive move in the context of climate change projections. Some retailers are already introducing limited time-of-use pricing for some customer classes. This trend can be expected to accelerate, with the outcome ultimately being a substantial increase in summer and winter peak electricity prices for customer classes not already subject to time-of-use pricing.
Water and sewage disposal costs	↑	↑	The Queensland Government is currently investing in major new water assets, including new dams (Traveston Crossing and Wyaralong), a desalination plant at Tugun on the Gold Coast, extra groundwater sources and the Western Corridor Recycled Water Scheme in response to the Millennium Drought in southeast Queensland. These new water assets will be linked to existing water sources, treatment plants and bulk water transport networks via regional inter-connector pipelines. The resulting Water Grid will facilitate water sharing and ensure that water can be moved to where it is needed across SE Queensland. A new State owned entity, the Water Grid Manager, will operate the Grid (in accordance with Water Market Rules to be established by the Queensland Water Commission). Thus, southeast Queensland Council water service providers will hand ownership of major water sources, trunk pipelines and water treatment plants to the State Government. The water and wastewater reticulation and wastewater treatment plants will be transitioned to a new single water distribution business by July 2010, with the retail functions moving to a separate retail business at the same time. New Local Government owned retail and distribution businesses will be created from the previous southeast Queensland Council water service providers by no later than July 2010. As part of these new arrangements, Redlands Water and Wastewater (RWW) will be handed over to the State Government (with compensation), although RCC will retain management of the reticulation system for water distribution up to 2010. Hence,

Policy Issue	Indicative Change		Discussion and Comments
	Short term	Medium term	
			water and wastewater management are not within scope for the current study. Bulk water prices will need to rise to cover the cost of the new water infrastructure, commencing 1 July 2008, with a direct cost pass through to retail bills. There will be a 'phasing in' approach for increased prices over a 10-year period. Although water and wastewater management are not within scope for the current study, the risks of rising prices on Council's assets, services and activities are within scope. Current bulk water prices for Redlands are set to increase from $548/ML in 2007/08 to $1,570 by 2013/14 (a 65% increase over the next five years), ultimately rising to $2,755 by 2017/18 (the end date for the current price path). It is assumed that water charges will still be affordable for most households. Impacts on some non-residential customers that are large water users, could be modelled to determine if there was likely to be a serious impact on financial viability
Solid waste management costs	↑	↑	The Queensland Government through the EPA is currently in the process of developing a new Queensland Waste Strategy. It is intended that the strategy will guide waste management in Queensland for the next 20 years. Key principles guiding the strategy include waste avoidance and user pays and the Government has signalled its intention to introduce policies aimed at reducing waste going landfill (e.g. landfill levies). These directions have been driven by general 'sustainability' objectives including in relation to GHG emissions. Inclusion of waste emissions in the CPRS is likely to reinforce this trend.
Other regulatory and compliance costs	↑	↑	Compliance costs in areas relevant to climate change response are likely to increase in the future: The Building Code of Australia was revised in 2006 to include a range of energy efficiency provisions for new commercial (class 5 to 9) buildings. Although, the provisions are designed to be cost-effective, additional up-front costs will undoubtedly be involved for building developments.

8. Appendix 3: Risk Workshop Participants

< List to follow >